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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
10/077,185	02/15/2002	Christoph Schwald	BP-66	9510

7590 07/16/2004

FRIEDRICH KUEFFNER
SUITE 1921
342 MADISON AVENUE
NEW YORK, NY 10173

EXAMINER	
CHIANG, JACK	
ART UNIT	**PAPER NUMBER**
2642	9

DATE MAILED: 07/16/2004

Please find below and/or attached an Office communication concerning this application or proceeding.

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PTO 90C (Rev 10/03)

Office Action Summary	Application No. 10/077185	Applicant(s) G. Schwald	
	Examiner J. Chiang	Group Art Unit 2642	#9

—The MAILING DATE of this communication appears on the cover sheet beneath the correspondence address—

7/1/

Period for Response

A SHORTENED STATUTORY PERIOD FOR RESPONSE IS SET TO EXPIRE --3-- MONTH(S) FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a response be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If the period for response specified above is less than thirty (30) days, a response within the statutory minimum of thirty (30) days will be considered timely.
- If NO period for response is specified above, such period shall, by default, expire SIX (6) MONTHS from the mailing date of this communication .
- Failure to respond within the set or extended period for response will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133).

Status

☒ Responsive to communication(s) filed on 2-15-02.

☐ This action is **FINAL.**

☐ Since this application is in condition for allowance except for formal matters, **prosecution as to the merits is closed** in accordance with the practice under *Ex parte Quayle,* 1935 C.D. 1 1; 453 O.G. 213.

Disposition of Claims

☒ Claim(s) 1-6 is/are pending in the application.

Of the above claim(s) ______ is/are withdrawn from consideration.

☐ Claim(s) ______ is/are allowed.

☒ Claim(s) 1-6 is/are rejected.

☐ Claim(s) ______ is/are objected to.

☐ Claim(s) ______ are subject to restriction or election requirement.

Application Papers

☐ See the attached Notice of Draftsperson's Patent Drawing Review, PTO-948.

☐ The proposed drawing correction, filed on ______ is ☐ approved ☐ disapproved.

☐ The drawing(s) filed on ______ is/are objected to by the Examiner.

☐ The specification is objected to by the Examiner.

☐ The oath or declaration is objected to by the Examiner.

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Priority under 35 U.S.C. § 119 (a)-(d)

☒ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 11 9(a)-(d).

☒ All ☐ Some* ☐ None of the CERTIFIED copies of the priority documents have been

☒ received.

☐ received in Application No. (Series Code/Serial Number) ______.

☐ received in this national stage application from the International Bureau (PCT Rule 1 7.2(a)).

*Certified copies not received: ______.

Attachment(s)

☒ Information Disclosure Statement(s), PTO-1449, Paper No(s). ______

☒ Notice of References Cited, PTO-892

☐ Notice of Draftsperson's Patent Drawing Review, PTO-948

☐ Interview Summary, PTO-413

☐ Notice of Informal Patent Application, PTO-152

☐ Other ______

Office Action Summary

USPTO TO PROVIDE ELECTRONIC ACCESS TO CITED U.S. PATENT REFERENCES WITH OFFICE ACTIONS AND CEASE SUPPLYING PAPER COPIES

In support of its 21st Century Strategic Plan goal of increased patent e-Government, beginning in June 2004, the United States Patent and Trademark Office (Office or USPTO) will begin the phase-in of its E-Patent Reference program and hence will: (1) **provide downloading capability of the U.S. patents and U.S. patent application publications cited in Office actions** via the E-Patent Reference feature of the Office's Patent Application Information Retrieval (PAIR) system; and (2) **cease mailing paper copies of U.S. patents and U.S. patent application publications with Office actions** (in applications and during reexamination proceedings) except for citations made during the international stage of an international application under the Patent Cooperation Treaty (PCT). In order to use the new E-Patent Reference feature applicants must: (1) obtain a digital certificate and software from the Office; (2) obtain a customer number from the Office; and (3) properly associate patent applications with the customer number. Alternatively, copies of all U.S. patents and patent application publications can be accessed without a digital certificate from the USPTO web site, from the USPTO Office of Public Records, and from commercial sources. The Office will continue the practice of supplying paper copies of foreign patent documents and non-patent literature with Office actions. Paper copies of cited references will continue to be provided by the USPTO for international applications during the international stage.

Schedule

June 2004	TCs 1600, 1700, 2800 and 2900
July 2004	TCs 3600 and 3700
August 2004	TCs 2100 and 2600

All U.S. patents and U.S. patent application publications are available on the USPTO web site. However, a simple system for downloading the <u>cited</u> U.S. patents and patent application publications has been established for applicants, called the E-Patent Reference system. As E-Patent Reference and Private PAIR require participating applicants to have a customer number, retrieval software and a digital certificate, all applicants are strongly encouraged to contact the Patent Electronic Business Center to acquire these items. To be ready to use this system by June 1, 2004, contact the Patent EBC as soon as possible by phone at 866-217-9197 (toll-free), 703-305-3028 or 703-308-6845 or electronically via the Internet at ebc@uspto.gov.

Other Options

The E-Patent Reference function requires the applicant to use the secure Private PAIR system, which establishes confidential communications with the applicant. Applicants using this facility must receive a digital certificate, as described above. Other options for obtaining patents which do not require the digital certificate include the USPTO's free Patents on the Web program (http://www.uspto.gov/patft/index.html). The USPTO's Office of Public Records also supplies copies of patents for a fee (http://ebiz1.uspto.gov/oems25p/index.html). Commercial sources also provide U.S. patents and patent application publications.

For complete instructions see the Official Gazette Notice, USPTO TO PROVIDE ELECTRONIC ACCESS TO CITED U.S. PATENT REFERENCES WITH OFFICE ACTIONS AND CEASE SUPPLYING PAPER COPIES, on the USPTO web site.

Steps to Use the New E-Patent Reference Feature During the Pilot Project and Thereafter

Access to private PAIR is required to utilize E-Patent Reference. If you don't already have access to private PAIR, the Office urges practitioners, and applicants not represented by a practitioner, to take advantage of the transition period to obtain a no-cost USPTO Public Key Infrastructure (PKI) digital certificate, obtain a USPTO customer number, associate all of their pending and new application filings with their customer number, install no-cost software (supplied by the Office) required to access private PAIR and E-Patent Reference feature, and make appropriate arrangements for Internet access. The full instructions for obtaining a PKI digital certificate are available at the Office's Electronic Business Center (EBC) web page at: <http://www.uspto.gov/ebc/downloads.html>. Note that a notarized signature will be required to obtain a digital certificate.

To get a Customer Number, download and complete the Customer Number Request form, PTO-SB125, at: http://www.uspto.gov/web/forms/sb0125.pdf. The completed form can then be transmitted by facsimile to the Electronic Business Center at (703) 308-2840, or mailed to the address on the form. If you are a registered attorney or patent agent, then your registration number must be associated with your customer number. This is accomplished by adding your registration number to the Customer Number Request form. A description of associating a customer number with an application is described at the EBC web page at: http://www.uspto.gov/ebc/registration_pair.html.

The E-Patent Reference feature will be accessed using a new button on the private PAIR screen. Ordinarily all of the cited U.S. patent and U.S. patent application publication references will be available over the Internet using the Office's new E-Patent Reference feature. The size of the references to be downloaded will be displayed by E-Patent Reference so the download time can be estimated. Applicants and registered practitioners can select to download all of the references or any combination of cited references. Selected references will be downloaded as complete documents as Adobe Portable Document Format (.pdf) files. For a limited period of time, the USPTO will include a copy of this notice with Office actions to encourage applicants to use this new feature and, if needed, to take the steps outlined above in order to be able to utilize this new feature during the pilot and thereafter.

During the two-month pilot, the Office will evaluate the stability and capacity of the E-Patent Reference feature to reliably provide electronic access to cited U.S. patent and U.S. patent application publication references. While copies of U.S. patent and U.S. patent application publication references cited by examiners will continue to be mailed with Office actions during the pilot project, applicants are encouraged to use the private PAIR and the E-Patent Reference feature to electronically access and download cited U.S. patent and U.S. patent application publication references so the Office will be able to objectively evaluate its performance. The public is encouraged to submit comments to the Office on the usability and performance of the E-Patent Reference feature during the pilot. Further, during the pilot period registered practitioners, and applicants not represented by a practitioner, are encouraged to experiment with the feature, develop a proficiency in using the feature, and establish new internal processes for using the new access to the cited U.S. patents and U.S. patent application publications to prepare for the anticipated cessation of the current Office practice of supplying copies of such cited

NOTICE OF OFFICE PLAN TO CEASE SUPPLYING COPIES OF CITED U.S. PATENT REFERENCES WITH OFFICE ACTIONS, AND PILOT TO EVALUATE THE ALTERNATIVE OF PROVIDING ELECTRONIC ACCESS TO SUCH U.S. PATENT REFERENCES

Summary

The United States Patent and Trademark Office (Office or USPTO) plans in the near future to: (1) cease mailing copies of U.S. patents and U.S. patent application publications (US patent references) with Office actions except for citations made during the international stage of an international application under the Patent Cooperation Treaty and those made during reexamination proceedings; and (2) provide electronic access to, with convenient downloading capability of, the US patent references cited in an Office action via the Office's private Patent Application Information Retrieval (PAIR) system which has a new feature called "E-Patent Reference." Before ceasing to provide copies of U.S. patent references with Office actions, the Office shall test the feasibility of the E-Patent Reference feature by conducting a two-month pilot project starting with Office actions mailed after December 1, 2003. The Office shall evaluate the pilot project and publish the results in a notice which will be posted on the Office's web site (www.USPTO.gov) and in the Patent Official Gazette (O.G.). In order to use the new E-Patent Reference feature during the pilot period, or when the Office ceases to send copies of U.S. patent references with Office actions, the applicant must: (1) obtain a digital certificate from the Office; (2) obtain a customer number from the Office, and (3) properly associate applications with the customer number. The pilot project does not involve or affect the current Office practice of supplying paper copies of foreign patent documents and non-patent literature with Office actions. Paper copies of references will continue to be provided by the USPTO for searches and written opinions prepared by the USPTO for international applications during the international stage and for reexamination proceedings.

Description of Pilot Project to Provide Electronic Access to Cited U.S. Patent References

On December 1, 2003, the Office will make available a new feature, E-Patent Reference, in the Office's private PAIR system, to allow more convenient downloading of U.S. patents and U.S. patent application publications. The new feature will allow an authorized user of private PAIR to download some or all of the U.S. patents and U.S. patent application publications cited by an examiner on form PTO-892 in Office actions, as well as U.S. patents and U.S. patent application publications submitted by applicants on form PTO/SB08 (1449) as part of an IDS. The retrieval of some or all of the documents may be performed in one downloading step with the documents encoded as Adobe Portable Document format (.pdf) files, which is an improvement over the current page-by-page retrieval capability from other USPTO systems.

references. The Office plans to continue to provide access to the E-Patent Reference feature during its evaluation of the pilot.

Comments

Comments concerning the E-Patent Reference feature should be in writing and directed to the Electronic Business Center (EBC) at the USPTO by electronic mail at eReference@uspto.gov or by facsimile to (703) 308-2840. Comments will be posted and made available for public inspection. To ensure that comments are considered in the evaluation of the pilot project, comments should be submitted in writing by January 15, 2004.

Comments with respect to specific applications should be sent to the Technology Centers' customer service centers. Comments concerning digital certificates, customer numbers, and associating customer numbers with applications should be sent to the Electronic Business Center (EBC) at the USPTO by facsimile at (703) 308-2840 or by e-mail at EBC@uspto.gov.

Implementation after Pilot

After the pilot, its evaluation, and publication of a subsequent notice as indicated above, the Office expects to implement its plan to cease mailing paper copies of U.S. patent references cited during examination of non provisional applications on or after February 2, 2004; although copies of cited foreign patent documents, as well as non-patent literature, will still be mailed to the applicant until such time as substantially all applications have been scanned into IFW.

For Further Information Contact

Technical information on the operation of the IFW system can be found on the USPTO website at http://www.uspto.gov/web/patents/ifw/index.html. Comments concerning the E-Patent Reference feature and questions concerning the operation of the PAIR system should be directed to the EBC at the USPTO at (866) 217-9197. The EBC may also be contacted by facsimile at (703) 308-2840 or by e-mail at EBC@uspto.gov.

Date. 12/1/03

Nicholas P. Godici

Nicholas P. Godici
Commissioner for Patents

FORM PTO-892 (REV. 2-92)

U.S. DEPARTMENT OF COMMERCE
PATENT AND TRADEMARK OFFICE

NOTICE OF REFERENCES CITED

SERIAL NO.	GROUP ART UNIT	ATTACHMENT TO PAPER NUMBER
10/077185	2642	9

APPLICANT(S): C. Schwald

U.S. PATENT DOCUMENTS

*		DOCUMENT NO.	DATE	NAME	CLASS	SUB-CLASS	FILING DATE IF APPROPRIATE
	A	2002/0094101	7-18-02	De Roo Et Al.	381	356	1-12-01
	B	6091830	7-18-00	Toki	381	356	6-3-97
	C						
	D						
	E						
	F						
	G						
	H						
	I						
	J						
	K						

FOREIGN PATENT DOCUMENTS

*		DOCUMENT NO.	DATE	COUNTRY	NAME	CLASS	SUB-CLASS	PERTINENT SHTS. DWG	PERTINENT PP. SPEC.
	L								
	M								
	N								
	O								
	P								
	Q								

OTHER REFERENCES (Including Author, Title, Date, Pertinent Pages, Etc.)

	R	
	S	
	T	

CLAIMS

1. The following is a quotation of the appropriate paragraphs of 35 U.S.C. 102 that form the basis for the rejections under this section made in this Office action:

> A person shall be entitled to a patent unless –
>
> (b) the invention was patented or described in a printed publication in this or a foreign country or in public use or on sale in this country, more than one year prior to the date of application for patent in the United States.
>
> (e) the invention was described in (1) an application for patent, published under section 122(b), by another filed in the United States before the invention by the applicant for patent or (2) a patent granted on an application for patent by another filed in the United States before the invention by the applicant for patent, except that an international application filed under the treaty defined in section 351(a) shall have the effects for purposes of this subsection of an application filed in the United States only if the international application designated the United States and was published under Article 21(2) of such treaty in the English language.

2. Claims 1-2 and 5 are rejected under 35 U.S.C. 102(e) as being anticipated by De Roo et al. (US 2002/0094101).

Regarding claim 1, De Roo shows:

A microphone housing (housing 30);

A microphone capsule (enclosing/supporting 39 or 70);

Front sound entry openings (32);

Front volume (36);

Rear sound entry openings (34);

Rear volume (38);

The front and rear volumes are in communication with front and rear sound entry openings of the microphone capsule respectively;

A connecting volume (i.e. 80) connecting the front volume (36) and the rear volume (38).

Regarding claims 2 and 5, De Roo shows:

The connecting volumes can be narrow ducts (80 or 42);

Knobs or webs (40 or 72) for supporting the microphone capsule.

3. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

> (a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

4. Claims 1-5 are rejected under 35 U.S.C. 103(a) as being unpatentable over Toki (US 6091830) in view of De Roo et al.

Claims 3-4, 6 are rejected under 35 U.S.C. 103(a) as being unpatentable over De Roo et al in view of Toki .

Regarding claim 1, Toki shows:

A microphone housing (9);

A microphone capsule (11);

Front sound entry openings (2);

Front volume (space for 4);

Rear sound entry openings (8);

Rear volume (space for 7);

The front and rear volumes are in communication with front and rear sound entry openings of the microphone capsule respectively.

Toki differs from the claimed invention in that it does not have a connecting volume connecting the front volume and the rear volume.

However, De Roo teaches providing a connecting volume (i.e. 80) connecting the front volume (36) and the rear volume (38) in a microphone housing design.

Hence, it would have been obvious for one of ordinary skill in the art to modify Toki's microphone housing with a connecting volume connecting the front volume and the rear volume as taught by De Roo, this modification would improve low frequency roll-off for the microphone (see Abstract in De Roo).

Regarding claims 2 - 6, the combination of Toki and De Roo shows:

The connecting volumes can be narrow ducts, or annular gap can be considered as a design preference as long as it can achieve the same function as the ducts (80, page 3, paragraph 0043 in De Roo);

Sound permeable foam components (4, 7 in Toki);

Knobs or webs (40 or 72 in De Roo; 10 in Toki) for supporting the microphone capsule;

Further, the height of the front volume is dictated by the design criteria for the microphone frequency pattern, and is considered as a design preference and would have been obvious for one of ordinary skill in the art. In other words, the height of the front volume can be varied depending on what the microphone frequency pattern is in the design criteria.

5. Any inquiry concerning this communication or earlier communications from the examiner should be directed to Jack Chiang whose telephone number is 703-305-4728. The examiner can normally be reached on Mon.-Fri. from 8:00 to 6:30.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Ahmad Matar, can be reached on 703-305-4731. The fax phone number for the organization where this application or proceeding is assigned is 703-872-9306.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free).

Jack Chiang
Primary Examiner
Art Unit 2642

Sheet 1 of 1

Form PTO-1449 LIST OF PRIOR ART CITED BY APPLICANT	Docket No.: BP-66	Serial No.: 10/077,185
	Applicant: Christoph Schwald	
	Filing Date: February 15, 2002	Group:

U.S. PATENT DOCUMENTS

Exam. Init.		Document Number	Date	NAME	Class	Subclass	Filing Date if appropriate
	AA	4 9 6 6 2 5 2	10/90	DREVER			
	AB						
	AC						
	AD						
	AE						
	AF						
	AG						
	AH						
	AI						

FOREIGN PATENT DOCUMENTS

		Document Number	Date	COUNTRY	Class	Subclass	TRANSLATION Yes	No
	AJ	0 1 3 0 4 0 0	1/85	EUROPEAN				X
	AK	298 13 397 U1	12/98	GERMANY				X
	AL							
	AM							
	AN							
	AO							

OTHER PRIOR ART *(Including Author, Title, Date, Pertinent Pag s, Etc.)*

	AP	
	AQ	
	AR	

EXAMINER J. Chiang	DATE CONSIDERED 7-6-04

US006091830A

United States Patent [19]

Toki

[11] **Patent Number: 6,091,830**

[45] **Date of Patent: Jul. 18, 2000**

[54] **TRANSMITTER STRUCTURE FOR LIMITING THE EFFECTS OF WIND NOISE ON A MICROPHONE**

[75] Inventor: **Nozomi Toki**, Tokyo, Japan

[73] Assignee: **NEC Corporation**, Tokyo, Japan

[21] Appl. No.: **08/867,997**

[22] Filed: **Jun. 3, 1997**

[30] **Foreign Application Priority Data**

Jul. 19, 1996 [JP] Japan 8-190598

[51] **Int. Cl.**[7] **H04R 25/00**

[52] **U.S. Cl.** **381/359**; 381/357; 381/356

[58] **Field of Search** 381/359, 360, 381/355, 356, 357, 188

[56] **References Cited**

U.S. PATENT DOCUMENTS

2,560,354	7/1951	Kettler	381/357
4,151,378	4/1979	Watson .	
4,975,966	12/1990	Sapiejewski	381/359
5,282,245	1/1994	Anderson	379/433
5,442,713	8/1995	Patel et al.	381/168
5,701,354	12/1997	Komoda et al.	381/157
5,703,957	3/1997	McAteer	381/92
5,781,643	7/1998	Anderson	381/168
5,859,916	1/1999	Ball et al.	381/326
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0 661 902 A2	7/1995	European Pat. Off. .
0 707 403 A2	4/1996	European Pat. Off. .
6-269084	9/1994	Japan .
6-73991	10/1994	Japan .
7-20742	4/1995	Japan .
7-99536	4/1995	Japan .
7-202997	8/1995	Japan .
2 064 267	6/1981	United Kingdom .
WO 94/06256	3/1994	WIPO .

Primary Examiner—Curtis A. Kuntz
Assistant Examiner—Dionne N. Harvey
Attorney, Agent, or Firm—Scully, Scott, Murphy & Presser

[57] **ABSTRACT**

A transmitter structure which is resistance to wind noise and the like and allows a reduction in size is disclosed. A sound hole is formed in a case at an offset position with respect to a microphone, and a slit extending from the sound hole to the microphone is filled with an acoustic resistance cloth.

4 Claims, 2 Drawing Sheets

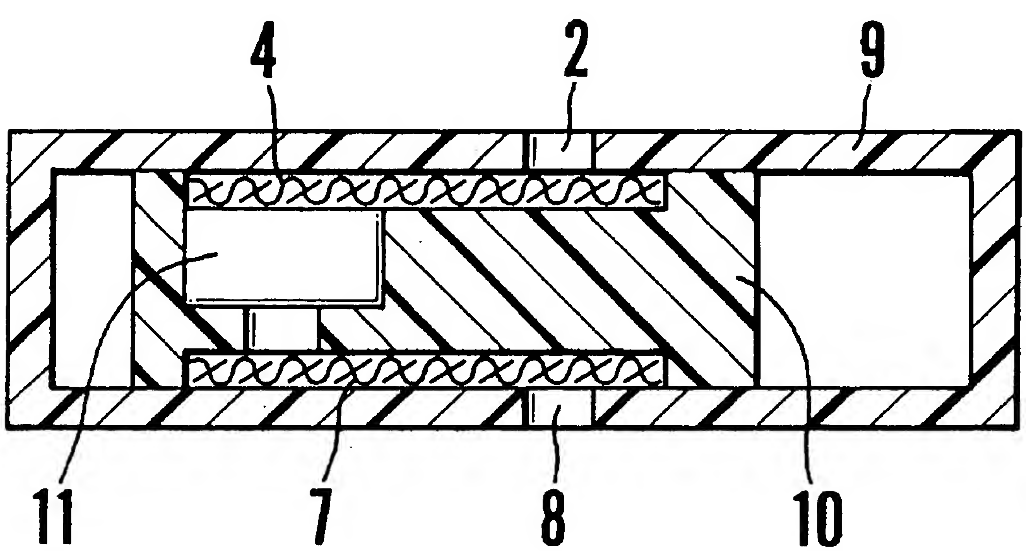


FIG. 1

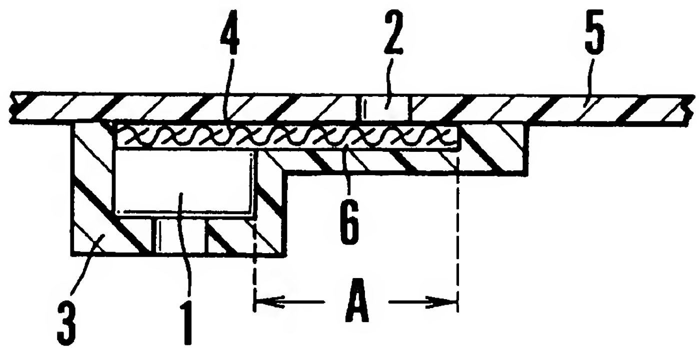
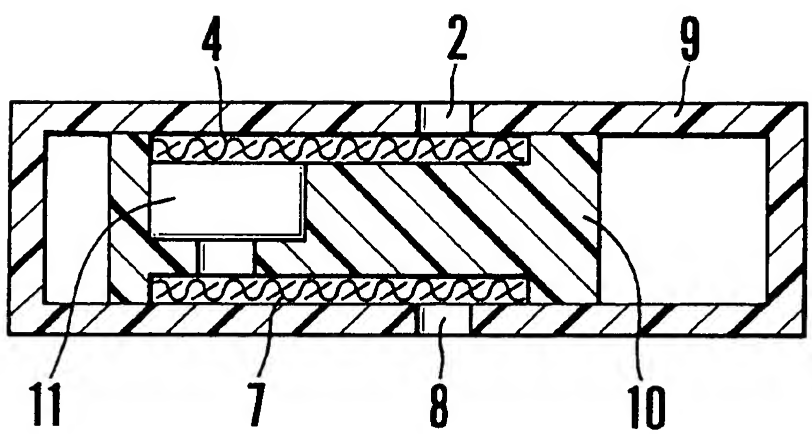


FIG. 2



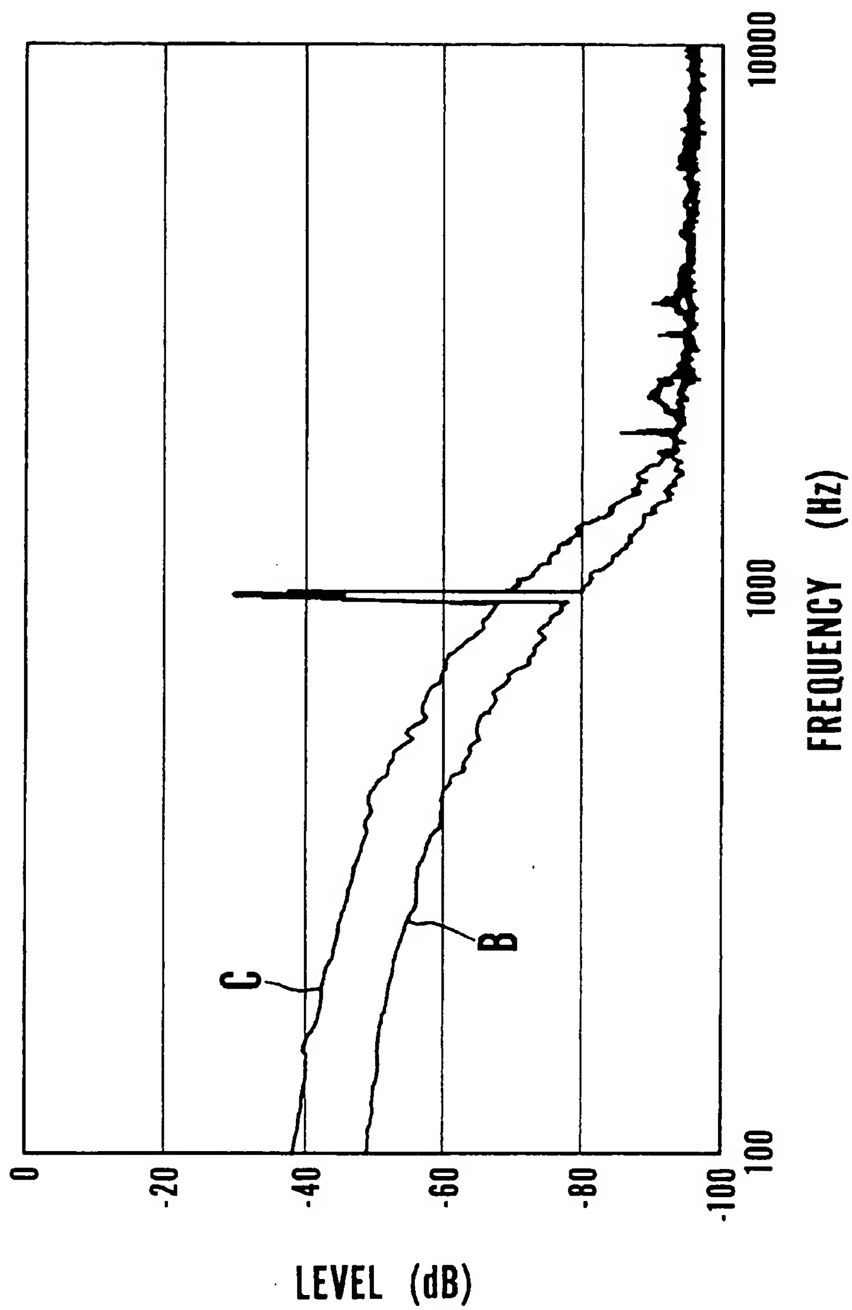


FIG. 3

TRANSMITTER STRUCTURE FOR LIMITING THE EFFECTS OF WIND NOISE ON A MICROPHONE

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a transmitter structure and, more particularly, to the transmitter structure of a portable electronic device, e.g., a portable telephone or a video camera, which is used outdoors and designed to reduce wind noise.

2. Description of the Prior Art

Various transmitter structures designed to reduce noise caused by user's breath and wind in outdoor use have been proposed.

For example, Japanese Unexamined Patent Publication No. 6-269084 discloses a technique of controlling the cutoff frequency of a high-pass filter for reducing wind noise by using a detection means for detecting wind on the basis of differential outputs from two microphones.

In another transmitter structure disclosed in Japanese Unexamined Patent Publication No. 7-202997, the sound hole formed in the case is connected to the microphone through a sound path to prevent breath from directly entering the microphone.

Since the above conventional transmitter structure has a filter for reducing wind noise and a wind detection circuit, a reduction in cost is difficult to attain.

In addition, since two microphones are used, it is difficult for this structure to realize a compact electronic device for which portability is required, in particular.

Furthermore, the structure having the sound path needs to weaken breath and wind in the sound path to reduce the amount of wind or the like reaching the microphone. For this reason, the width, height, and length of the wind path are respectively set to about 2.5 mm, 0.5 mm, and 25 mm. Especially the length must be set to 25 mm or more. This structure is not therefore suited for a reduction in size, either.

A pressure gradient microphone such as a directional or close-talking microphone is susceptible to the influence of wind, in particular, as compared with a non-directional microphone. It is therefore difficult to apply such a microphone to a portable telephone, a video camera, and the like which are used outdoors.

SUMMARY OF THE INVENTION

The present invention has been made to solve the above problem, and has as its object to provide a transmitter structure which uses one microphone but does not require a circuit for reducing wind noise and the like.

It is another object of the present invention to provide a transmitter structure which allows a reduction in size and can reduce wind noise and the like.

In order to achieve the above objects, according to the present invention, there is provided a transmitter structure comprising a microphone, a first sound hole formed in a case on a front side of the microphone, a first slit for connecting the microphone to the sound hole, and a first acoustic resistance cloth which fills the slit.

The slit preferably has a width of 2.5 mm, a height of 0.3 mm, and a length of 10 mm.

The structure may further include a second sound hole formed in the case on a rear side of the microphone, a second slit for connecting the second sound hole to the rear side of

the microphone, and a second acoustic resistance cloth which fills the second slit.

When the microphone is a pressure gradient microphone such as a directional or close-talking microphone, the present invention exhibits its effect.

As described above, in the transmitter structure of the present invention, the slit filled with the acoustic resistance cloth serves as a wind screen to reduce wind noise and the like.

Since the acoustic resistance is proportional to the thickness and length of the acoustic resistance cloth, a compact structure can be realized.

In addition, when arrangements similar to the above arrangement are formed on the front and read sides of a pressure gradient microphone, a structure resistance to wind noise can be provided.

According to the present invention, since the wind noise reducing effect can be obtained by the slit formed on the front side of the microphone and filled with the acoustic resistance cloth, no special circuit for reducing wind noise is required, realizing a reduction in cost.

In addition, since the thin acoustic resistance cloth is used for the relatively short slit, a compact structure can be realized.

Furthermore, since the acoustic resistance cloths are used for the sound holes formed on the front and read sides of the microphone, a directional or close-talking microphone which is resistant to wind noise can be realized.

The above and many other objects, features and advantages of the present invention will become manifest to those skilled in the art upon making reference to the following detailed description and accompanying drawings in which preferred embodiments incorporating the principles of the present invention are shown by way of illustrative example.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a sectional view showing an embodiment of the present invention;

FIG. **2** is a sectional view showing another embodiment of the present invention; and

FIG. **3** is a graph showing the frequency characteristics of the embodiment shown in FIG. **2**.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

The present invention will be described in detail below with reference to the accompanying drawings.

FIG. **1** is a sectional view showing an embodiment of the present invention.

Referring to FIG. **1**, a transmitter structure comprises a microphone **1**, a sound hole **2**, a microphone holder **3**, an acoustic resistance cloth **4**, a case **5**, and a slit **6**.

The sound hole **2** is formed in a portion of the case **5**. The sound hole **2** is connected to the front portion of the microphone **1** through the slit **6** formed in the microphone holder **3** supporting the microphone **1**. The front portion is located on the right side in FIG. **1**. The microphone **1** is therefore spaced apart from the sound hole **2** through the slit **6**, i.e., located at an offset position. The microphone holder **3** is fixed to the case **5**.

This slit **6** may extend from the position of the sound hole **2**, or may extend from a portion closer to the front side than the sound hole **2** to the microphone **1**. The front side is located on the right side in FIG. **1**.

The slit 6 is filled with a damping cloth or acoustic resistance cloth 4 which has the property of transmitting sounds but does not allow dust and the like to pass through it. The acoustic resistance cloth 4 may fill only the slit 6 or may extend to the front portion of the microphone 1.

The slit 6 preferably has a width of about 2.5 mm, a height of about 0.3 mm, and a length of about 10 mm. In this case, "a length of about 10 mm" corresponds to a portion A between the distal end portion of the microphone 1 and an end portion of the slit 6. The acoustic resistance cloth 4 preferably has a thickness of about 0.3 to 0.5 mm.

The operation of the present invention will be described next.

Wind, breath, or the like entering the sound hole 2 reaches the diaphragm at the front portion of the microphone 1 through the slit 6. The acoustic resistance cloth 4 filling the slit 6 serves as a wind screen for blocking the wind or the like entering the sound hole 2. The function of the wind screen increases in effect as the acoustic resistance increases. The effect therefore increases as the thickness of the acoustic resistance cloth 4 increases. In the present invention, since the acoustic resistance effect is based on the thickness and length of the acoustic resistance cloth, a compact structure can be realized.

In addition, since no air chamber or the like is required in the slit 6, the disturbances in frequency characteristics due to acoustic capacitance are small.

FIG. 2 is a sectional view showing another embodiment of the present invention.

Referring to FIG. 2, a transmitter structure comprises sound holes 2 and 8, acoustic resistance cloths 4 and 7, a case 9, a microphone holder 10, and a microphone 11.

The microphone 11 is a pressure gradient microphone such as a directional or close-talking microphone. In this case, in addition to the sound hole 2 on the microphone front side, the sound hole 8 is formed on the microphone rear side. The microphone 11 of this type is a differential microphone which operates on the basis of the difference between sounds from the front and rear sides of the microphone 11.

The sound holes 2 and 8 are formed in the case 9 to oppose each other on the front and rear sides (the front and rear sides are respectively located on the right and left sides in FIG. 2) of the microphone 11. Slits filled with the acoustic resistance cloths 4 and 7 are formed in the microphone holder 10 to extend from the sound holes 2 and 8 to the microphone 11.

In this embodiment, similar to the first embodiment, the acoustic resistance cloths 4 and 7 serve as wind screens to block wind and the like entering the sound holes 2 and 8. For this reason, a pressure gradient microphone which is susceptible to the influence of wind, in particular, can be reduced in size.

FIG. 3 is a graph showing the frequency characteristics based on wind noise in the embodiment shown in FIG. 2.

FIG. 3 shows the frequency characteristics obtained with a 1-kHz single sound and wind generated by a fan using a close-talking microphone as the microphone 11, in comparison with a conventional structure having no slit. Each slit has a width of 2.5 mm, a height of 0.3 mm, and a length of 10 mm. Referring to FIG. 3, a curve B represents the embodiment of the present invention, and a curve C represents the prior art.

As is apparent from FIG. 3, a wind noise reduction effect of about 10 dB is obtained at 2 kHz or lower.

What is claimed is:

1. A transmitter structure comprising:

a microphone;

a case having at least one first sound hole formed therein on a front side of said microphone and offset from said microphone such that none of the sound holes or portions thereof are in direct communication with the microphone;

a microphone holder disposed within the case and having a support for supporting the microphone therein, the microphone holder further having a first interior channel acoustically connecting said front side of said microphone to said at least one first sound hole; and

a first acoustic resistance cloth which fills the first interior channel.

2. A structure according to claim 1, wherein the first interior channel has a width of 2.5 mm, a height of 0.3 mm, and a length of 10 mm.

3. A structure according to claim 1, further comprising at least one second sound hole formed in said case on a rear side of said microphone wherein said holder further having a second interior channel acoustically connecting said at least one second sound hole to the rear side of said microphone, and a second acoustic resistance cloth which fills said second interior channel.

4. A structure according to claim 3, wherein said microphone is a pressure gradient microphone including a directional microphone and a close-talking microphone.

* * * * *

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(54) WIND NOISE SUPPRESSION IN DIRECTIONAL MICROPHONES

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Publication Classification

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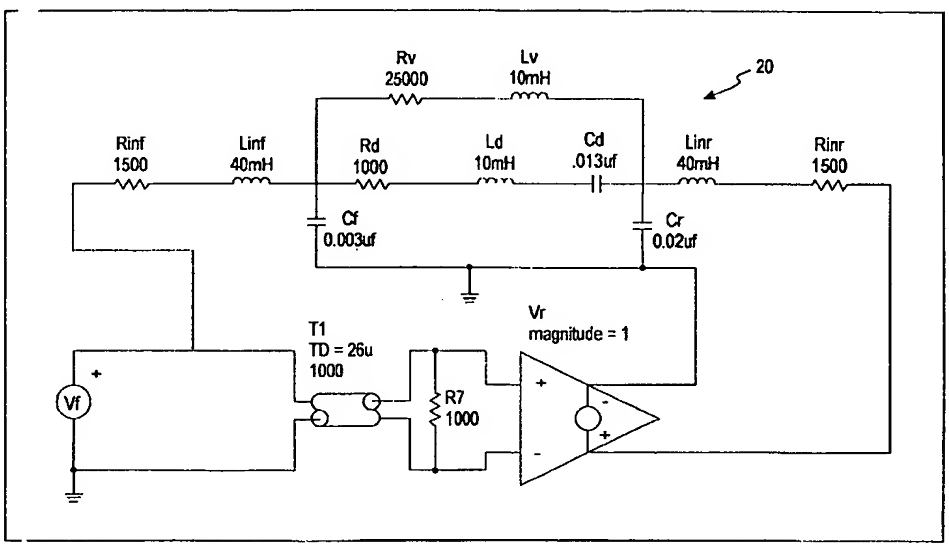
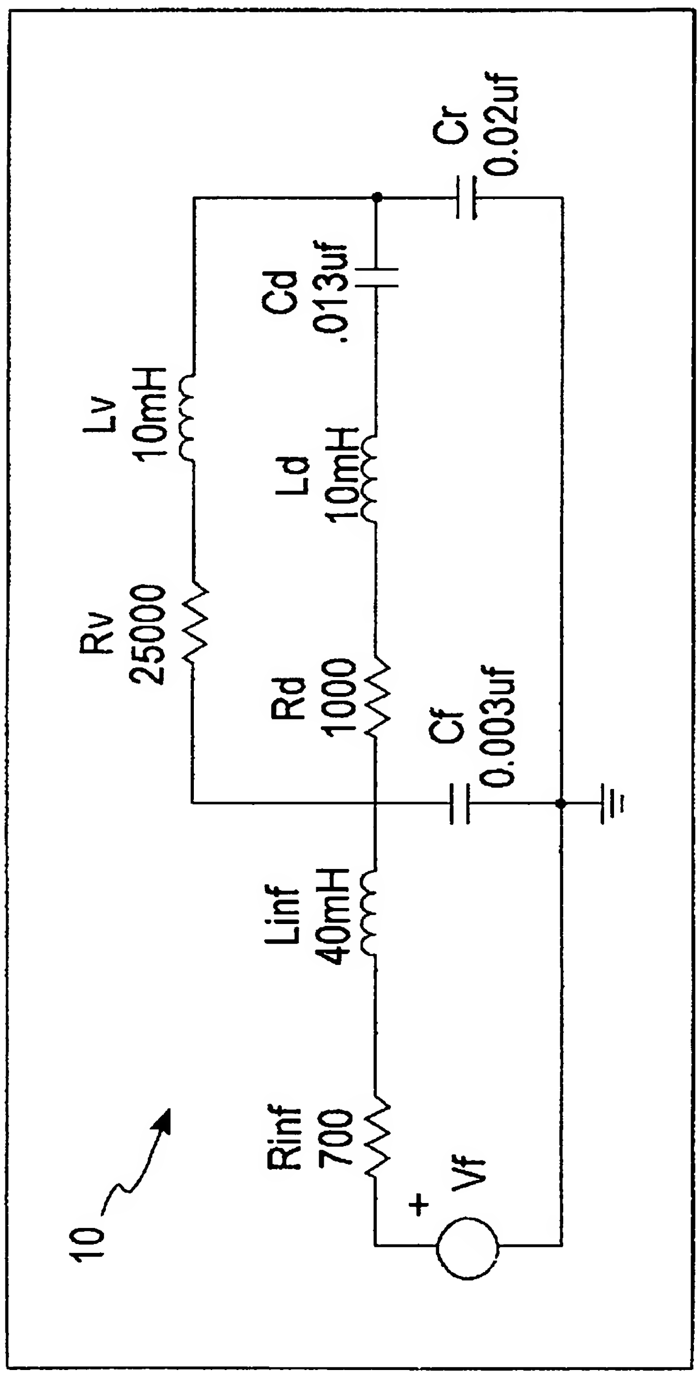
(52) U.S. Cl. 381/356; 381/357

(57) ABSTRACT

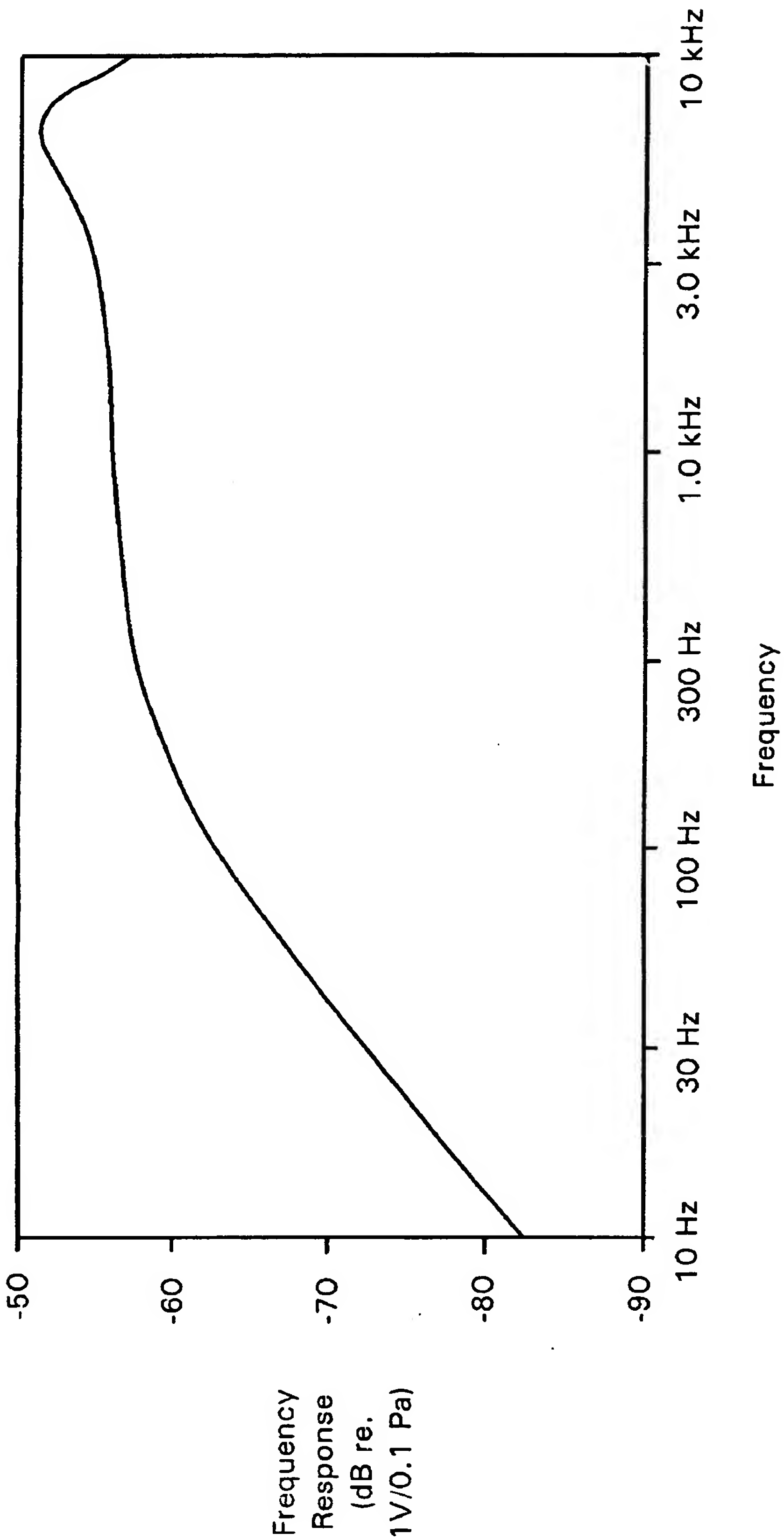
A directional microphone includes a housing, a diaphragm dividing the housing into a front volume and a back volume, electronics for detecting signals corresponding to movements of the diaphragm, and front and back inlets for the front and back volumes, respectively. To obtain additional low frequency roll-off in the directional microphone, the directional microphone includes an elongated acoustical conduit connecting the front volume and the back volume. The acoustical conduit may be external or internal to the housing.





10
Rinf
700
Vf
+
Linf
40mH
Rv
25000
Lv
10mH
Rd
1000
Ld
10mH
Cd
.013uf
Cf
0.003uf
Cr
0.02uf

Fig. 1A



-50
-60
-70
-80
-90
Frequency Response (dB re. 1V/0.1 Pa)
10 Hz
30 Hz
100 Hz
300 Hz
1.0 kHz
3.0 kHz
10 kHz
Frequency

Fig. 1B

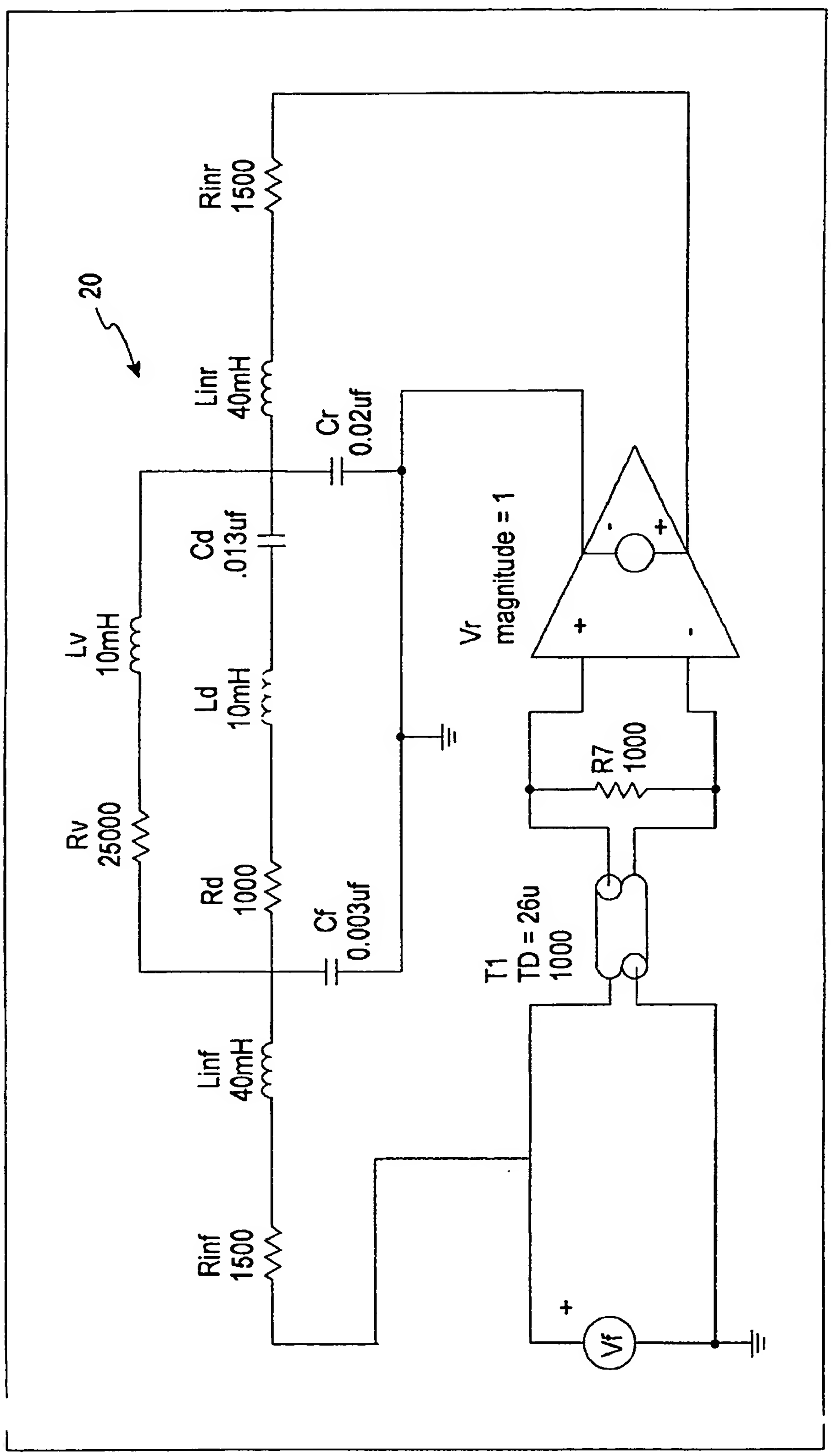

20
Rinr
1500
Linr
40mH
Cr
0.02uf
Cd
.013uf
Lv
10mH
Ld
10mH
Vr
magnitude = 1
Rv
25000
Rd
1000
R7
1000
Cf
0.003uf
T1
TD = 26u
1000
Linf
40mH
Rinf
1500
Vf

Fig. 2A

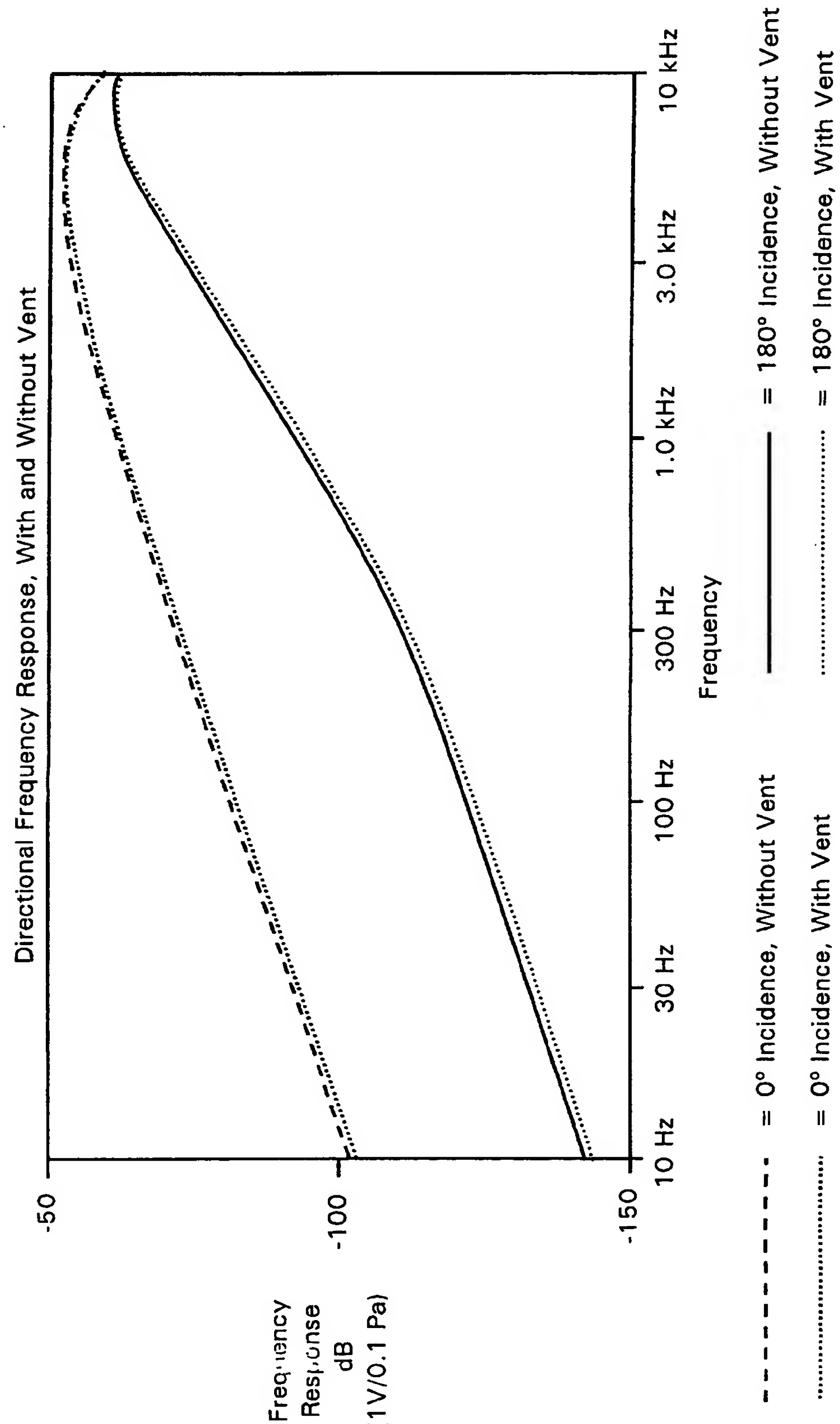

Directional Frequency Response, With and Without Vent
Frequency Response dB (1V/0.1 Pa)
-50
-100
-150
10 Hz
30 Hz
100 Hz
300 Hz
1.0 kHz
3.0 kHz
10 kHz
Frequency
= 0° Incidence, Without Vent
= 0° Incidence, With Vent
= 180° Incidence, Without Vent
= 180° Incidence, With Vent

Fig. 2B

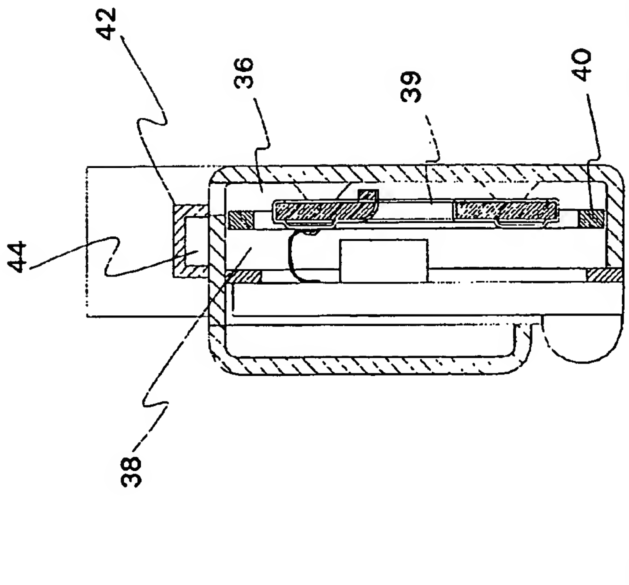


Fig. 3C

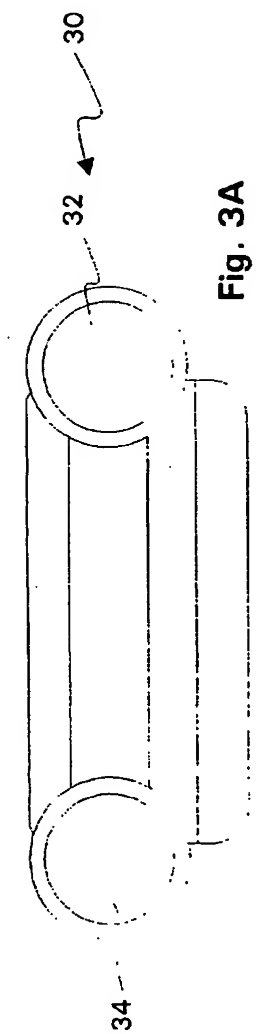


Fig. 3A

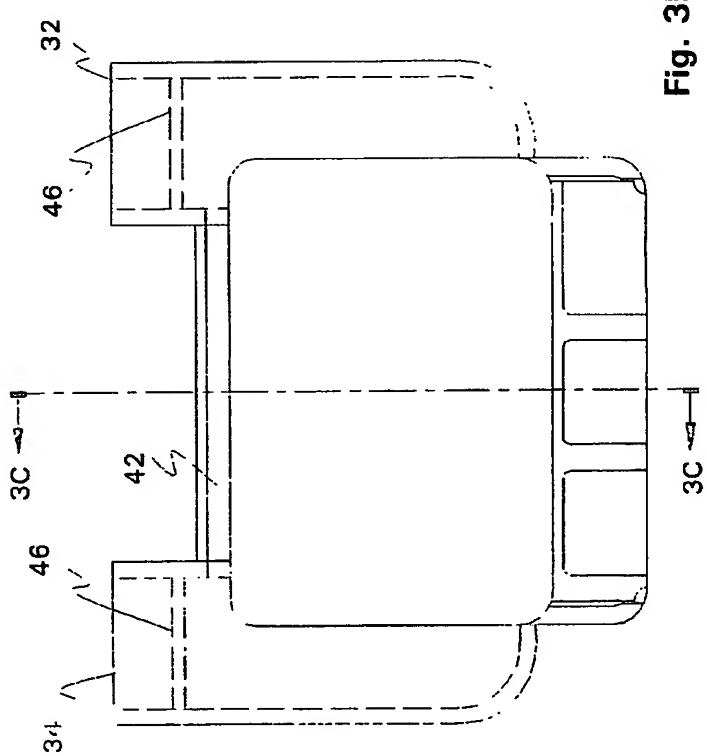


Fig. 3B

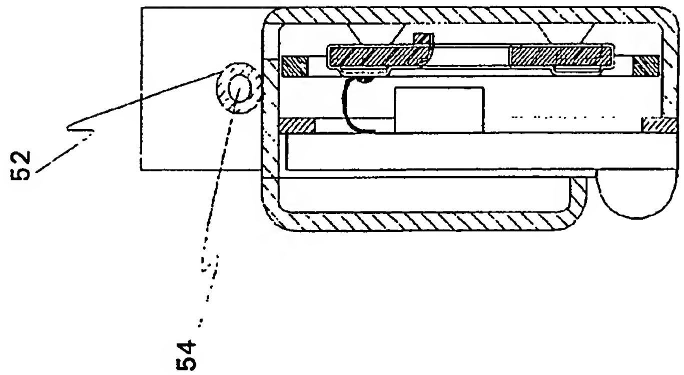


Fig. 4C

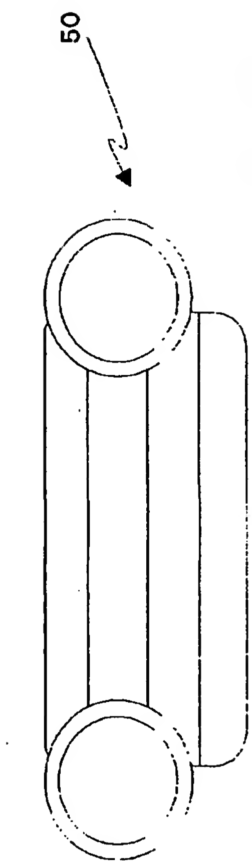


Fig. 4A

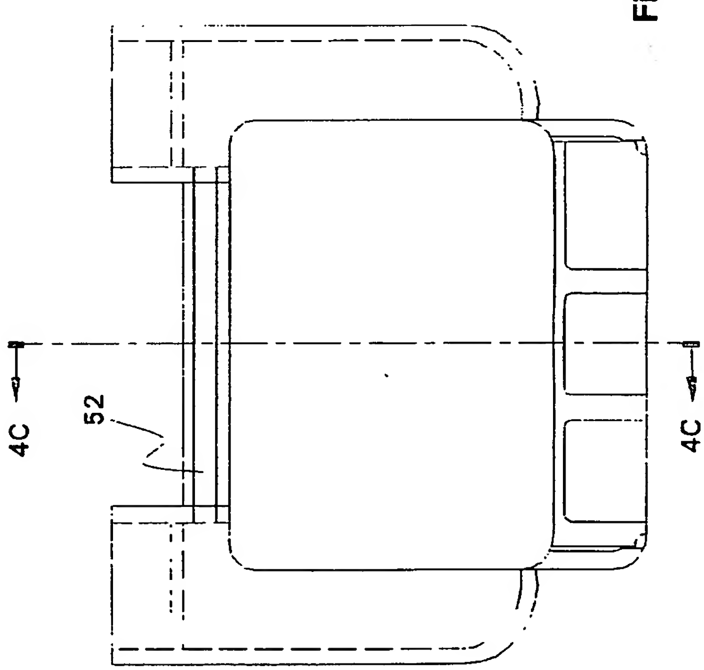


Fig. 4B

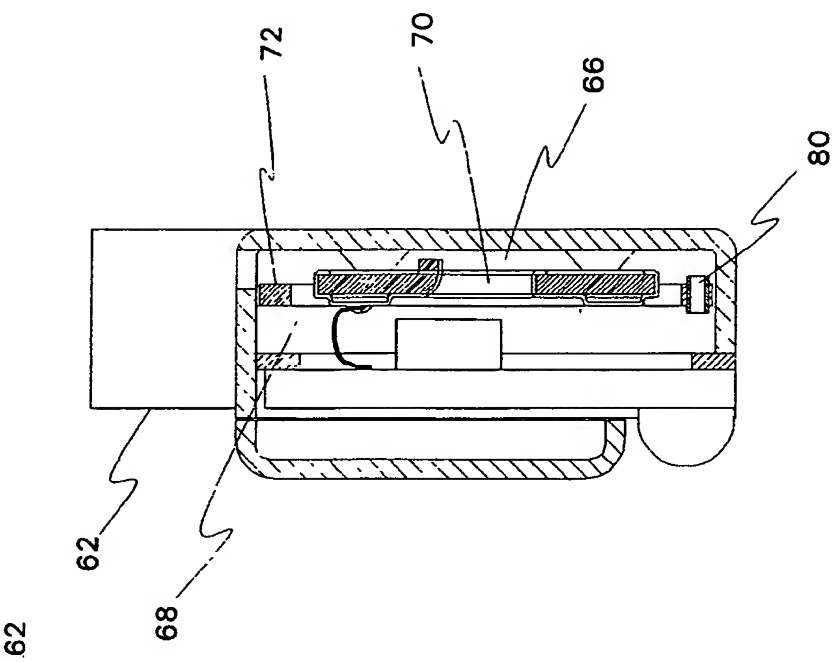


Fig. 5B

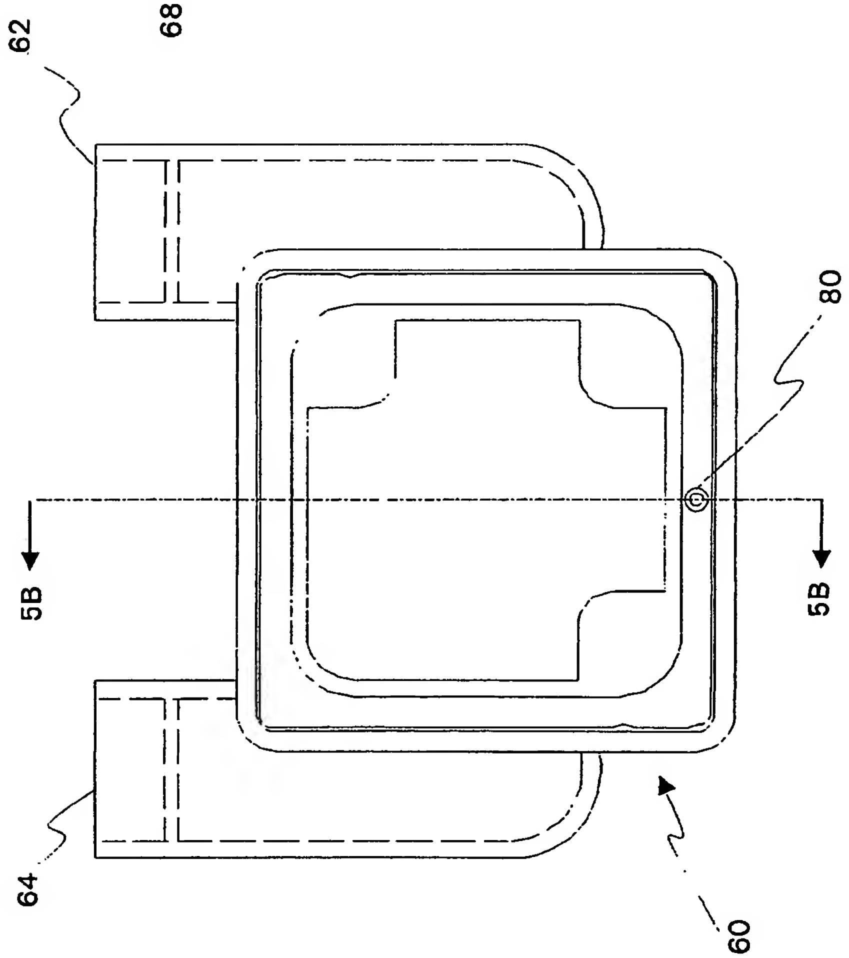
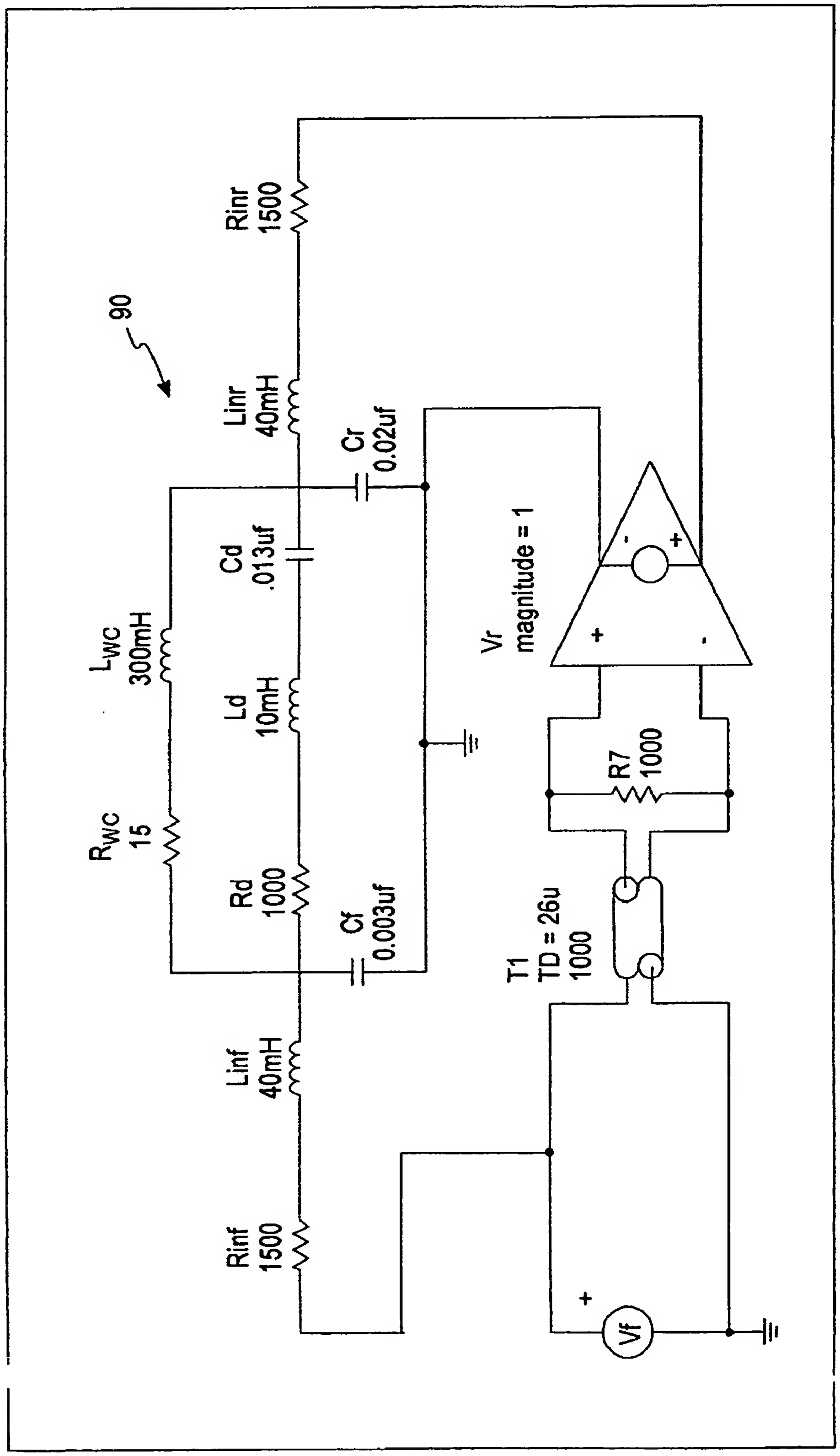


Fig. 5A



90
Rinr
1500
Linr
40mH
Cr
0.02uf
Cd
.013uf
LWC
300mH
Ld
10mH
RWC
15
Rd
1000
Cf
0.003uf
Linf
40mH
Rinf
1500
Vr
magnitude = 1
R7
1000
T1
TD = 26u
1000
Vf

Fig. 6

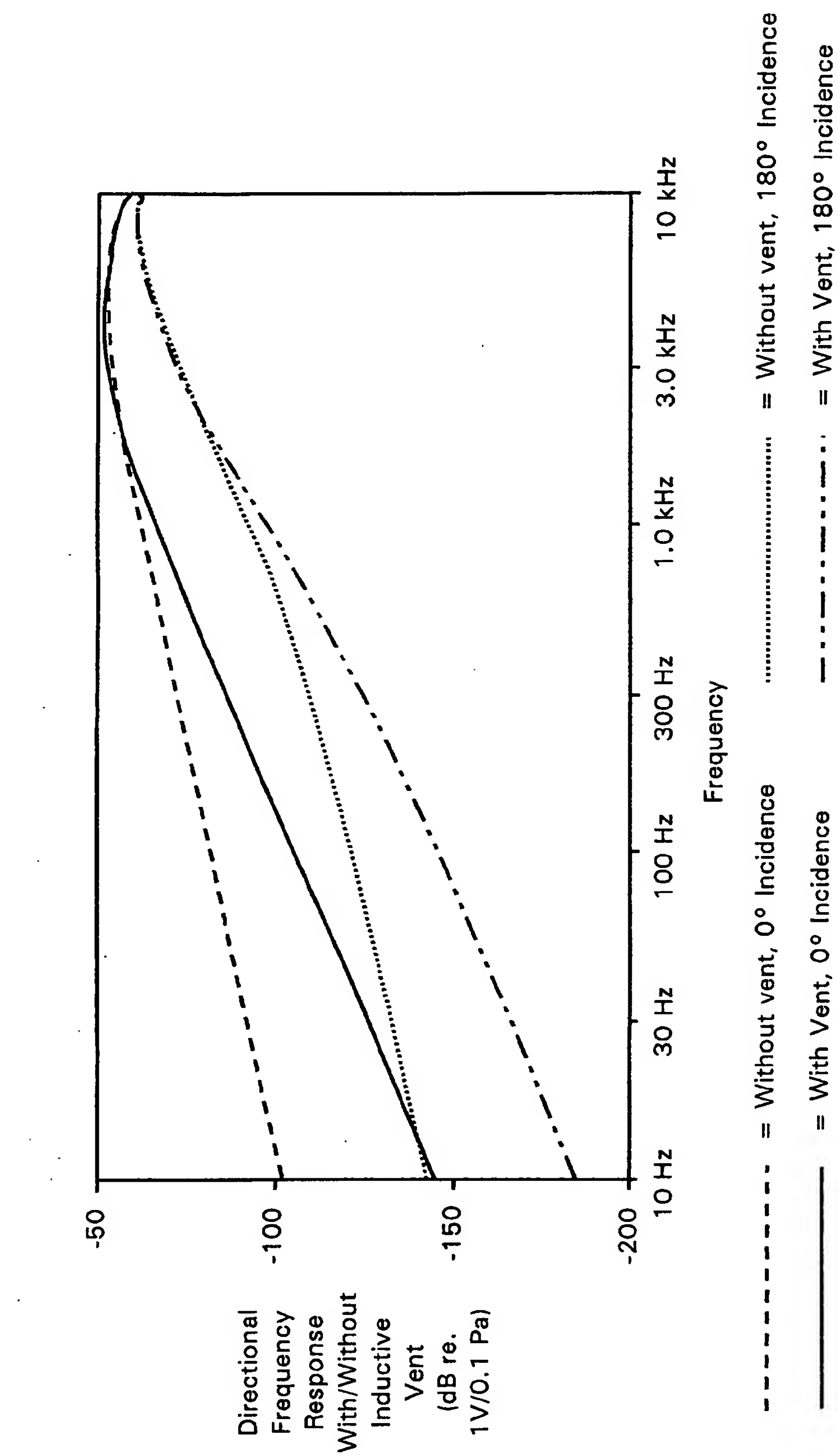
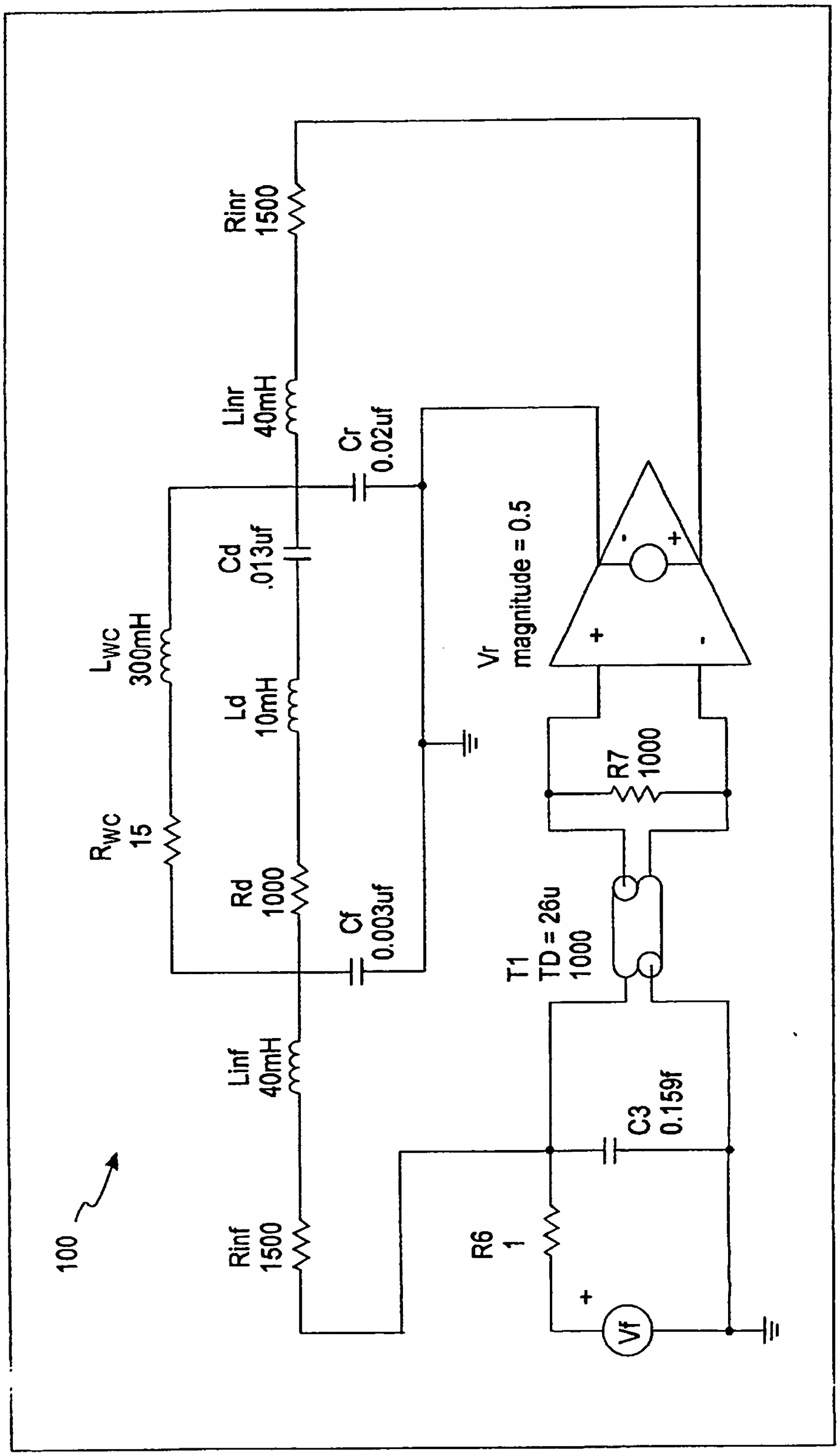

Directional Frequency Response With/Without Inductive Vent (dB re. 1V/0.1 Pa)
-50
-100
-150
-200
10 Hz
30 Hz
100 Hz
300 Hz
1.0 kHz
3.0 kHz
10 kHz
Frequency
= Without vent, 0° Incidence
= With Vent, 0° Incidence
= Without vent, 180° Incidence
= With Vent, 180° Incidence

Fig. 7



100
Rinf
1500
Linf
40mH
Rd
1000
Cf
0.003uf
Ld
10mH
Cd
.013uf
Linr
40mH
Cr
0.02uf
Rinr
1500
R_WC
15
L_WC
300mH
Vr
magnitude = 0.5
R7
1000
T1
TD = 26u
1000
C3
0.159f
R6
1
Vf

Fig. 8A

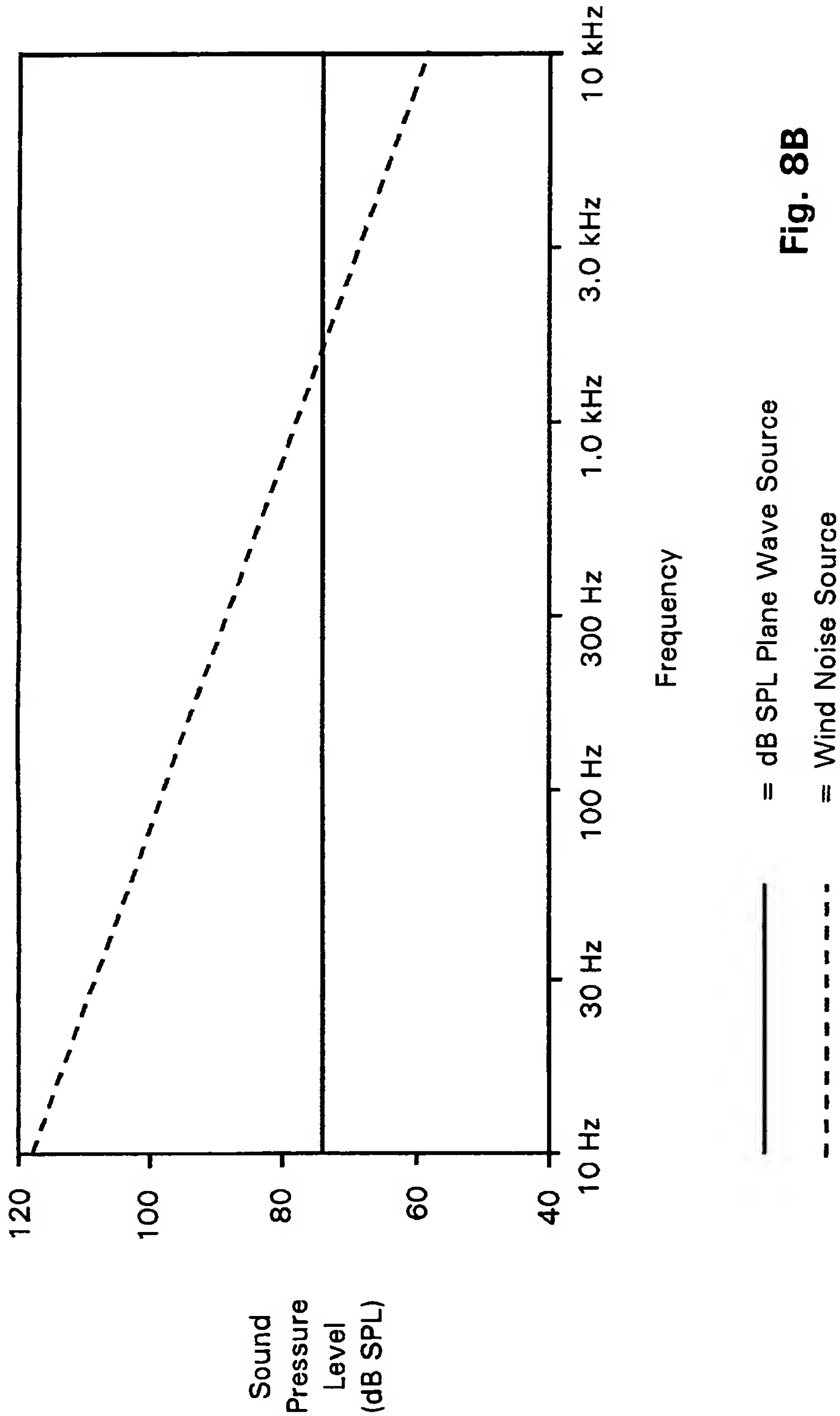

Sound Pressure Level (dB SPL)
120
100
80
60
40
10 Hz
30 Hz
100 Hz
300 Hz
1.0 kHz
3.0 kHz
10 kHz
Frequency
= dB SPL Plane Wave Source
= Wind Noise Source

Fig. 8B

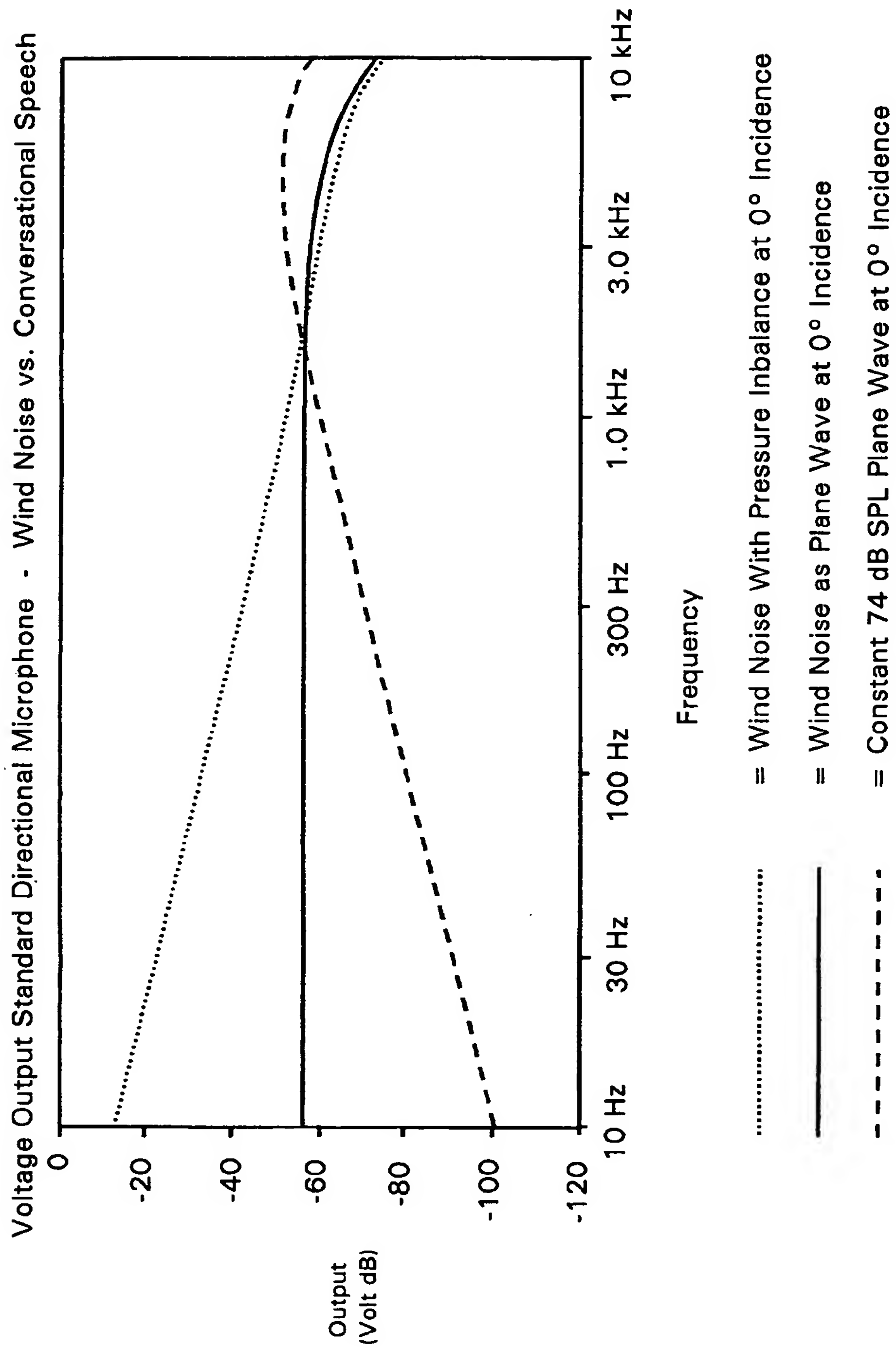

Voltage Output Standard Directional Microphone - Wind Noise vs. Conversational Speech
Output (Volt dB)
0
-20
-40
-60
-80
-100
-120
10 Hz
30 Hz
100 Hz
300 Hz
1.0 kHz
3.0 kHz
10 kHz
Frequency
= Wind Noise With Pressure Inbalance at 0° Incidence
= Wind Noise as Plane Wave at 0° Incidence
= Constant 74 dB SPL Plane Wave at 0° Incidence

Fig. 8C

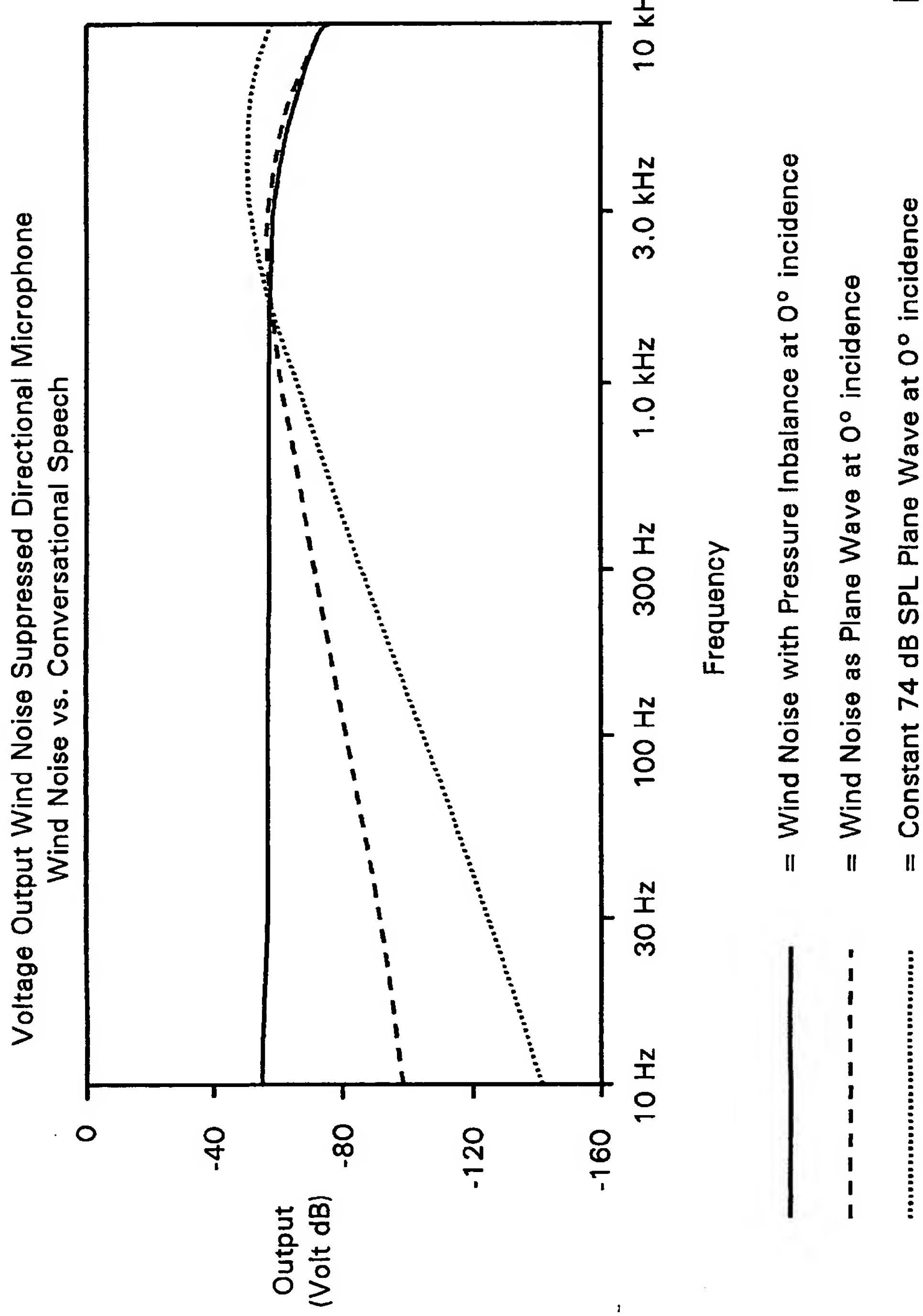

Voltage Output Wind Noise Suppressed Directional Microphone
Wind Noise vs. Conversational Speech
Output
(Volt dB)
0
-40
-80
-120
-160
10 Hz
30 Hz
100 Hz
300 Hz
1.0 kHz
3.0 kHz
10 kHz
Frequency
= Wind Noise with Pressure Inbalance at 0° incidence
= Wind Noise as Plane Wave at 0° incidence
= Constant 74 dB SPL Plane Wave at 0° incidence

Fig. 8D

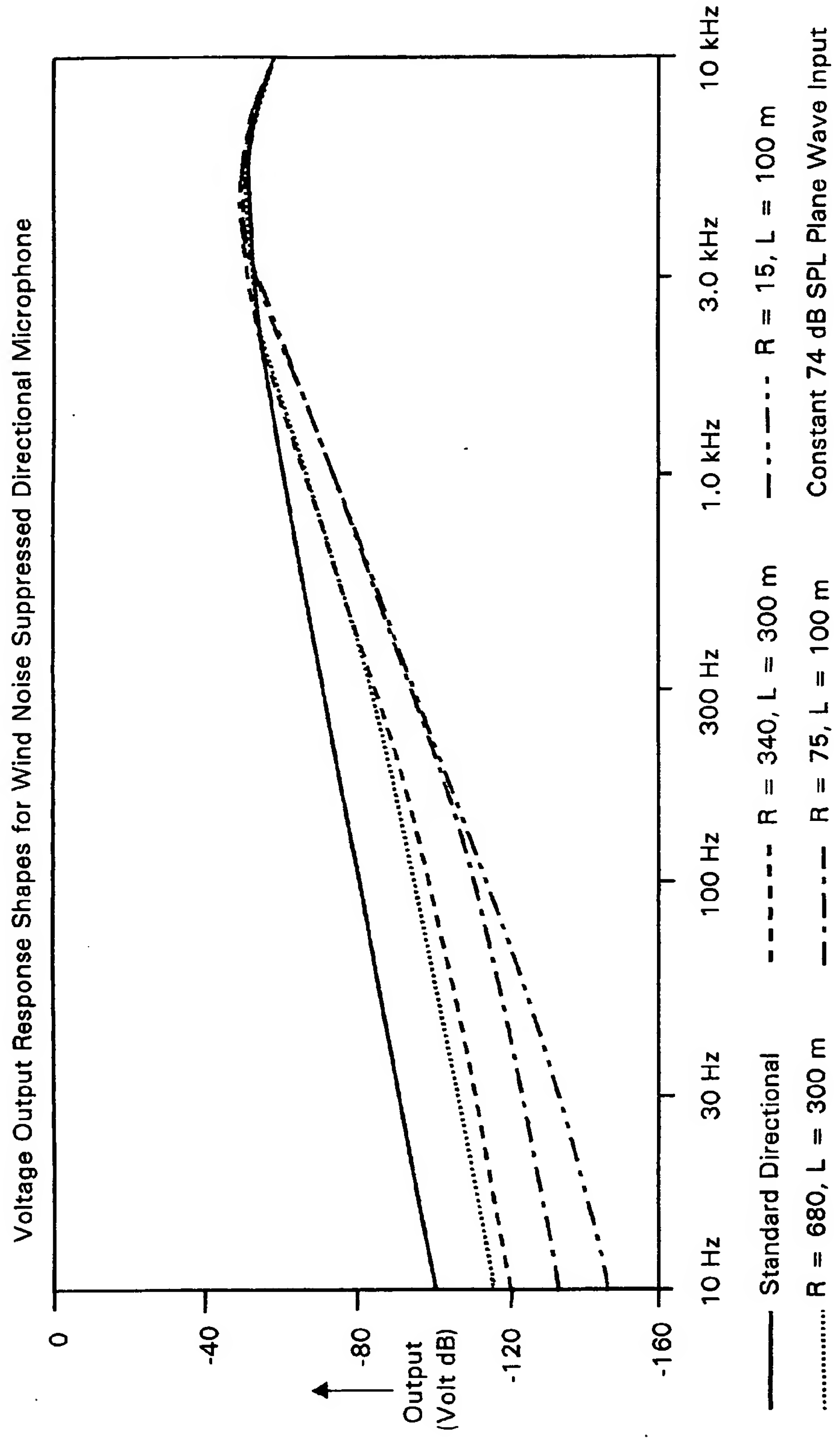

Voltage Output Response Shapes for Wind Noise Suppressed Directional Microphone
0
-40
-80
-120
-160
Output
(Volt dB)
10 Hz
30 Hz
100 Hz
300 Hz
1.0 kHz
3.0 kHz
10 kHz
Standard Directional
R = 340, L = 300 m
R = 15, L = 100 m
R = 680, L = 300 m
R = 75, L = 100 m
Constant 74 dB SPL Plane Wave Input

Fig. 9

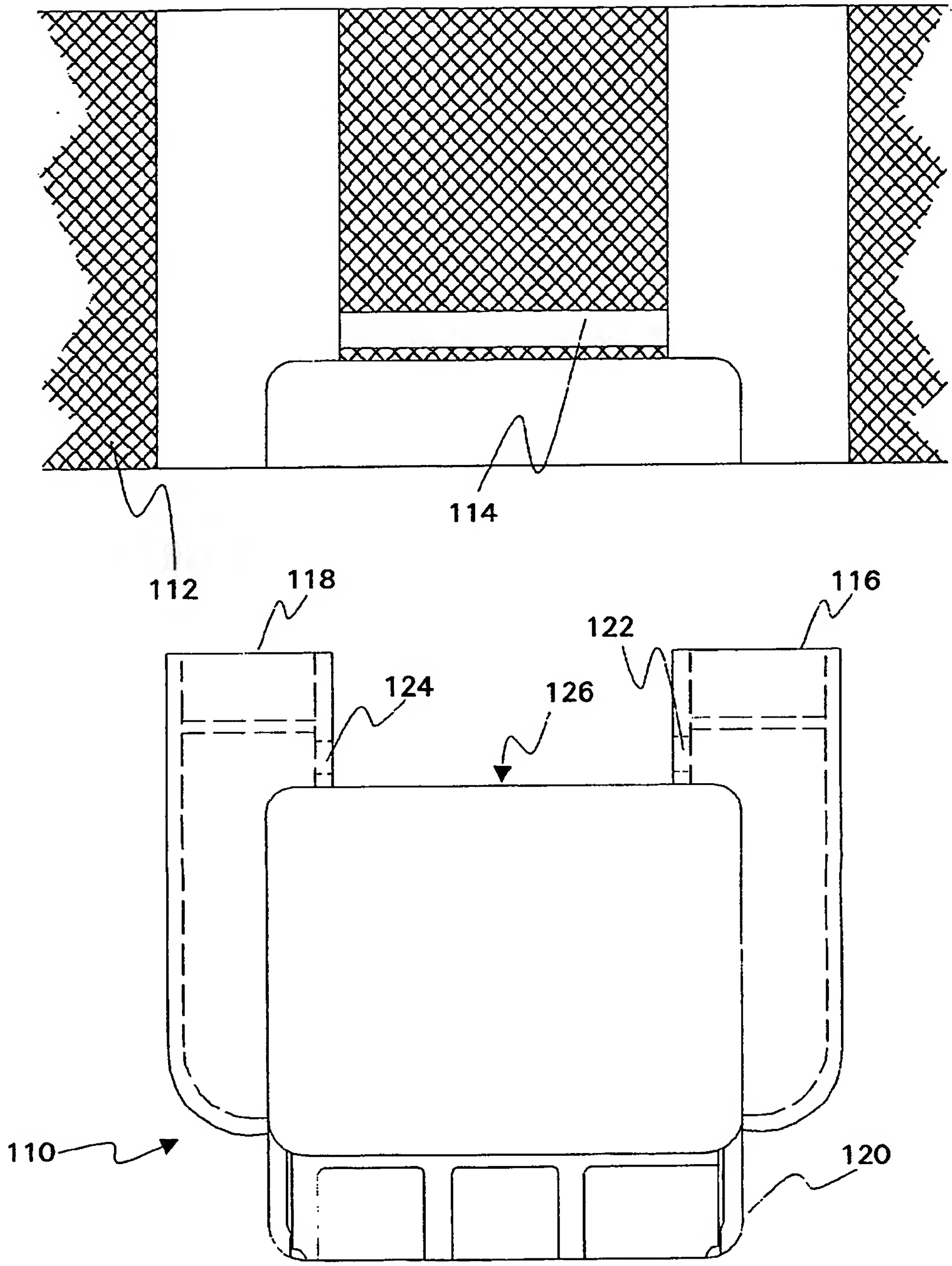


Fig. 10

WIND NOISE SUPPRESSION IN DIRECTIONAL MICROPHONES

RELATED APPLICATION

[0001] This application claims the benefit of priority to U.S. Provisional Patent Application Serial No. 60/261,493, filed Jan. 12, 2001.

FIELD OF THE INVENTION

[0002] The present invention relates to directional microphones and, specifically, to a directional microphone employing tubes or channels connecting the front and back volumes to reduce the undesirable effects of wind noise.

BACKGROUND OF THE INVENTION

[0003] Directional microphones have openings to both the front and back volumes and provide an output corresponding to the subtraction of two time delayed signals (i.e., the principle of directivity), resulting in a 6 dB/octave low frequency roll-off in their frequency response curves. Compared to pressure or omnidirectional microphones, the output for directional microphones is attenuated by the effective subtraction of the two input signals, while the noise is magnified by the presence of an essentially infinite rear or back volume. Therefore, the signal-to-noise ratio of directional microphones is much poorer at low frequencies, which makes them more sensitive to low frequency noise sources, like wind noise. A brief explanation of the properties of wind provides a better understanding of the problems that wind creates in directional microphones.

[0004] Air molecules are always in motion, but usually in a random direction. During a wind, the air molecules have an appreciable bias towards one direction. When an obstacle is met, the air is redirected. Sometimes the velocity of the air is decreased when an obstacle is met. For some obstacles, however, the velocity of the air increases and the air is diverted. The diverted air may produce a vortex where the air swirls in a circular motion. This vortex can have very high wind velocity and pressure. The sound produced by this vortex is usually of low frequency and acts as though it were coming from a point source in the vicinity of the vortex. For a low frequency point source, the phase difference at two loci close to the sound origin will be very small. The amplitude difference, however, can be very large.

[0005] Now consider the effect of a vortex caused by the presence of a directional microphone. The output of a directional microphone is related to the displacement of the diaphragm, which reacts to a difference in sound pressure between the front and back volumes. As said above, the turbulence of the wind causes a source of noise that is essentially a point source of low frequency sound at the center of the vortex. The signals received at both sound inlets will then be appreciably in phase, because the frequency is low and, therefore, the wavelength much greater than the spacing between the sound inlets. If the distance between the sound inlets is approximately the same distance as the distance from the closer inlet to the vortex, however, the further inlet will receive a sound 6 dB lower in level than the one arriving at the closer inlet. It is the pressure difference that causes the problem and results in a diaphragm displacement in the direction of the lowest pressure which, consequently, results in a relatively high microphone output. In effect, the directional microphone becomes a close-talking microphone for the wind turbulence, yet remains a directional microphone for plane wave or distant sounds. The problem is accentuated for wind noise since the amplitude of the sound from the wind can be very high, which may deafen the desired sounds, such as those from speech.

[0006] The current solution practiced in many directional hearing aids is to use an open celled foam cap or a protective mechanical flat screen or grid that is applied mostly in the faceplate of the hearing aid to smooth the turbulence. Although this solution appears to be helpful in practice, it has a great impact on the design of the faceplate or shell of a hearing aid since it may require more faceplate area, and/or additional parts, and/or additional production steps for assembly. These mechanical solutions do not, however, entirely solve the problem since the wind still produces an annoying sound to the wearer of the hearing aid. Further, the use of an electronic high pass filter may not be effective in situations where high SPL noise sources cause overload in the input stage of the microphone amplifier. Therefore, the low frequency noise signals should be attenuated before they cause distortion products in the high frequency spectrum. As such, there is still a strong desire in the market to reduce the effects of wind noise in directional microphones.

SUMMARY OF THE INVENTION

[0007] To solve the aforementioned problems, a wind noise suppression conduit is placed in the directional microphone to join the front and back volumes. The conduit may extend across the diaphragm internal to the housing of the microphone. Alternatively, the conduit may reside external to the housing of the microphone, connecting the front and back inlets leading to the front and back volumes, respectively, or the conduit may be formed by molding a mounting plate which connects the front and back volumes when positioned against the housing of the microphone.

[0008] The wind noise suppression conduit presents an acoustical mass (i.e., related to acoustical inertance, and the acoustic equivalent of an electrical inductance) that, together with the acoustical resistances of the mechanical screens in the sound inlets, causes a low frequency roll-off of 6 dB/octave. When added to the inherent frequency roll-off of a directional microphone that is typically 6 dB/octave, the overall microphone has a low frequency roll-off at 12 dB/octave for its frequency response. Accordingly, wind noise is suppressed such that the wearer of the hearing aid receives a reduced output of wind noise that provides much less of a tendency for the microphone to overload and also much less of a likelihood for low frequency masking by the wind noise of the higher frequencies of the speech signal.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] The foregoing and other advantages of the invention will become apparent upon reading the following detailed description and upon reference to the drawings.

[0010] **FIG. 1A** is an exemplary electrical schematic analogizing the acoustical network of a standard pressure or omni-directional microphone having a vent in the diaphragm.

[0011] **FIG. 1B** is a frequency response curve for the standard pressure or omni-directional microphone of **FIG. 1A**.

[0012] **FIG. 2A** is an exemplary electrical schematic analogizing the acoustical network of a directional microphone having a vent in the diaphragm.

[0013] **FIG. 2B** is a frequency response curve for the directional microphone of **FIG. 2A and a** directional microphone that lacks a vent in the diaphragm (i.e., a standard directional microphone).

[0014] FIGS. 3A-3C are an embodiment of the present invention employing an external wind noise suppression channel.

[0015] FIGS. 4A-4C are another embodiment of the present invention employing an external wind noise suppression tube.

[0016] FIGS. 5A-5B are yet another embodiment of the present invention employing an internal wind noise suppression tube.

[0017] **FIG. 6** is an exemplary electrical schematic analogizing the acoustical network of a directional microphone having an external or internal wind noise suppression tube/channel of the present invention.

[0018] **FIG. 7** is a frequency response curve that compares a standard directional microphone with a directional microphone that has an external or internal wind noise suppression tube of the present invention.

[0019] **FIG. 8A** is an exemplary electrical schematic analogizing the acoustical network of a directional microphone having an external or internal wind noise suppression tube with a wind noise as an input source.

[0020] **FIG. 8B** is a graph of the sound pressure levels of the wind noise source of **FIG. 8A and a** 74 dB SPL plane wave that represents conversational speech.

[0021] **FIG. 8C** illustrates the output of a standard directional microphone that lacks the wind noise suppression tube of the present invention.

[0022] **FIG. 8D** illustrates the output of a directional microphone having an external or internal wind noise suppression tube of the present invention.

[0023] **FIG. 9** illustrates the response shapes of various geometries of the wind noise suppression tube/channel by listing the acoustical resistance "R" and the inertance "L" of the tube.

[0024] **FIG. 10** illustrates a listening device which includes a mounting plate molded to form a wind noise suppression conduit and a directional microphone.

[0025] While the invention is susceptible to various modifications and alternative forms, specific embodiments have been shown by way of example in the drawings and will be described in detail herein. It should be understood, however, that the invention is not intended to be limited to the particular forms disclosed. Rather, the invention is to cover all modifications, equivalents, and alternatives falling within the spirit and scope of the invention as defined by the appended claims.

DESCRIPTION OF ILLUSTRATIVE EMBODIMENTS

[0026] To appreciate the present invention, reference is made to the well-known analogy between acoustical networks and electrical circuits. In this analogy, acoustical compliance is analogous to electrical capacitance, acoustical inertance (or mass) is analogous to electrical inductance, and acoustical resistance is analogous to electrical resistance. Several of the acoustical networks will be described as electrical networks with values placed on the components of the networks. It should be understood that the application of the present invention is not limited to only those values listed, but can be applied to directional microphones having various values for the acoustical resistances, acoustical compliances, and acoustical inertances of the components in their acoustical networks.

[0027] **FIG. 1A** illustrates an electrical schematic that is analogous to the acoustical network **10** for a standard pressure microphone. R_{inf} and L_{inf} are the acoustical resistance of the input screen placed in a front inlet and the acoustical inertance of the air in the inlet, respectively, of the standard pressure microphone.

[0028] R_d, L_d, and C_d are the acoustical resistance, acoustical inertance, and acoustical compliance of the diaphragm within the microphone. The resistance, R_d, is the resistance to the sound wave impinging on the diaphragm. The inertance, L_d, relates to the mass of the diaphragm. The compliance, C_d, relates to the spring effect of the diaphragm.

[0029] R_v and L_v are the acoustical resistance and inertance, respectively, of the vent in the diaphragm leading from the front volume to the back volume. The vent is placed in the diaphragm to equalize the pressure between the front and back volumes.

[0030] C_f and C_r are the compliances of the front volume and the back (rear) volume, respectively. They represent the ability of the air to be compressed and expanded under pressure in the front and back volumes. V_f represents the pressure from a sound source that would be entering the front volume.

[0031] The values placed adjacent to each of these acoustical components in the network **10** are representative of typical values for a Model 100-Series microphone from Microtronic, the assignee of the present application.

[0032] **FIG. 1B** is a frequency response curve of the microphone defined by the acoustical network **10** in **FIG. 1A**. For low frequencies, the slope of the line is about 6 dB per octave. Thus, the microphone having the acoustical network **10** of **FIG. 1A** has a 6 dB per octave roll-off for low frequencies.

[0033] **FIG. 2A** illustrates an electrical schematic that is analogous to the acoustical network **20** for a directional microphone that includes a vent in the diaphragm. Directional microphones are not usually constructed with a vent in the diaphragm, since there is no need for a vent to equalize the pressure due to the front and back volumes being opened to the ambient environment. However, the directional microphone represented by the acoustical network **20** includes a vent in the diaphragm to illustrate its effects. In one embodiment, the vent is a tube having a very small diameter (e.g., 45 to 60 microns) and a very short length that is the thickness of the diaphragm. Thus, the vent is a highly resistive component but with a low inductance (i.e., inertance).

[0034] All of the reference components in the acoustical network **20** shown in **FIG. 2B** are the same as in **FIG. 1A**,

except that the R_{inr} and L_{inr} are the acoustical resistance of the screen in the back (rear) inlet and the inertance of the rear inlet, respectively, of the directional microphone. The primary purpose of the screens in the front and rear inlets is to provide a net internal time delay (i.e., a phase shift) to sounds entering their respective volumes. The internal time delay of a directional microphone is set such that a desired polar directivity pattern is obtained. On the other hand, the primary purpose of the screens in omni-directional microphones and pressure microphones is to dampen the peak in the frequency response.

[0035] Further, a time delay circuit, which includes T_1, R_7 (R_7 is the terminating impedance and is set equal to the characteristic impedance of the delay line T1 in order to simulate a uni-directional plane wave), and the amplifier having Vr as an output leading to the rear inlet, represents the time lag between the sound wave entering the front and rear inlets. Thus, an external time delay, TD, of 26 microseconds is used in this directional microphone model and is a function of the distance between the front and back inlets. Because the magnitude of Vr and Vf are the same, **FIG. 2A** is modeling a plane wave of conversational speech where there is no pressure imbalance. In other words, the lower portion of the circuit in **FIG. 2A** is the modeling of the sound inputs (V_r and V_f) that are received in the front and rear inlets of a directional microphone having this type of acoustical network **20**.

[0036] **FIG. 2B** illustrates the frequency response curves for the acoustical network **20** in **FIG. 2A**, with and without the vent (i.e., with and without the upper branch having the acoustical resistance R_v and inertance L_v). As can be seen, sound waves having angles of incidence to the inlets of 0° (directly impinging the inlets) and 180° result in no change in the curve shape with the vent and without the vent. The reason is as follows. The sensitivity of a microphone is related to the acoustic volume velocity at the diaphragm. This is represented in the schematic of **FIG. 2A** by the current flowing through capacitor C_d. The diaphragm vent, with its resistance R_v and impedance L_v, causes a high impedance bypass path that, as a result, somewhat reduces the current through C_d. The effect is a resistive voltage divider of the vent, in series with the total screen resistors, R_{inf} and R_{inr}. Since the vent resistance is normally much larger than the mechanical screens in the back and front inlets, the attenuation due to the vent is often negligible. Accordingly, a simple vent in the diaphragm of a directional microphone will not result in a decrease in the roll-off at low frequencies.

[0037] FIGS. 3A-3C illustrate several views of a directional microphone employing an external wind noise suppression channel according to one embodiment of the present invention. A directional microphone **30** includes a front inlet **32** and a back inlet **34** that lead into a housing that includes a front volume **36** and a back volume **38**, respectively. A diaphragm **39** divides the front volume **36** from the back volume **38**. The diaphragm **39** is supported within the directional microphone **30** by a support structure **40** attached to the inside of the housing.

[0038] An external C-shaped channel **42** extends between the front inlet **32** and the back inlet **34**. The channel **42** has an internal opening **44** that acoustically connects the front inlet **32** and the back inlet **34**. The rectangular internal opening **44** is defined on three sides by the C-shaped channel **42** and one side by the external surface of the housing **42**. The intersections of the internal opening **44** and the inlets **32** and **34** are downstream from the screens **46** that are often placed within the inlets **32** and **34** to assist in developing the phase shift. It is these screens **46** that represent the R_{inf} and R_{inr} in the previous schematic of **FIG. 2A**.

[0039] FIGS. 4A-4C illustrate a a directional microphone **50** according to another embodiment of the present invention. The directional microphone **50** includes a cylindrical tube **52** having an internal circular opening **54** connects the front inlet **32** and the back inlet **34**. The theory of operation between the directional microphone **30** of FIGS. 3A-3C and the directional microphone **50** of FIGS. 4A-4C is the same, although the dimensions and shapes of the internal openings **44** and **54** are slightly different.

[0040] The lengths of the channel 42 and the tube **52** (i.e., the acoustical conduits) are usually in the range of about 1 mm to about 6 mm, and the openings **44** and **45** have dimensions (diameters) that range from about 0.05 mm to about 0.5 mm. Of course, the front inlet **32** and the back inlet **34** could be moved relative to each other to accommodate a certain length that produces a desirable effect in the performance of the microphone.

[0041] Further, the channel **42** or tube **52** can be formed as an integral part of the front and back inlets **32** and **34**. Thus, the assembly would then be a cap-like structure that fits onto the microphone. Such a structure could be molded of a plastic placed over the microphone housing and sealed along its periphery. As yet a further embodiment, the channel or tube could be an integral structure formed along an exterior wall of the housing between the inlets.

[0042] **FIGS. 5A and 5B** illustrate a different embodiment of the present invention in which a directional microphone **60** includes an internal connection between a front volume **66** and a back volume **68** that receives sound from a front inlet **62** and a back inlet **64**, respectively. The front volume **66** and the back volume **68** are separated by a diaphragm **70** that is mounted within the housing by a support frame **72**. An internal hollow tube **80** is mounted in the support frame **72**. The hollow tube **80** has a length of generally between 1 mm to 6 mm and an opening with a diameter of about 0.05 mm to about 0.5 mm. In addition to this embodiment, the invention contemplates supporting the hollow tube **80** with other structures such that the tube **80** may pierce the diaphragm and possibly the backplate. Further, the tube **80** can be integrally formed in the inner wall of the housing.

[0043] In yet a further embodiment, it may be desirable to have two wind noise suppression tubes or channels in parallel. Thus, one wind noise suppression tube or channel may be located outside the housing and another inside. Or, in other embodiments, there could be two tubes or channels within the interior or two tubes or channels on the exterior of the housing. As used herein, tubes and channels are types of conduits.

[0044] **FIG. 6** is an electrical schematic of an acoustical network **90** of a directional microphone of the present invention and is similar to the schematic of **FIG. 2A**. The only difference is that the highly resistive vent has been replaced by the elongated tube (or channel) of the present invention, which introduces a much larger inductive element

in the circuit (i.e., the increased acoustical inertance from the tube/channel) and a much smaller resistive element due to its larger diameter. Hence, the circuit now includes R_{wc} and L_{wc}, which are the resistance and inductance of a wind noise suppression channel/tube ("WC") that connects the front and back volumes of the directional microphone. The RL characteristics of the wind noise suppression channel/tube WC present, in essence, a high pass filter to the acoustical network **90**.

[0045] **FIG. 7** illustrates the effects of a wind noise suppression channel/tube in the directional microphone at 0° and 180° angles of incidence of the sound wave. The inductive characteristics of a directional microphone according to the present invention brought about through the external channel **42** of **FIG. 3C**, the external tube **52** of **FIG. 4C**, or the internal tube **80** of **FIG. 5B** cause an increase in the slope of the curves, resulting in a 12 dB/octave roll-off at the low frequencies, instead of only the 6 dB/octave roll-off caused by the subtraction of time delayed signals (i.e., the principle of directivity in a directional microphone due to the screens). Because wind noise is mainly a low frequency noise source, a directional microphone according to the present invention acts to suppress (and preferably cancel) these wind noises such that only the more desirable sounds are heard by the wearer of the hearing aid.

[0046] A comparison of **FIG. 2B** with **FIG. 7** yields two noteworthy observations. First, the curves for the no-vent model in **FIG. 2B** and the curve for the no-WC model in **FIG. 7** are identical, as would be expected. Second, the higher inductance from the wind noise suppression channel/tube substantially affects the shape of the curve.

[0047] **FIG. 8A** is an electrical schematics representation of an acoustical network **100** that models the effects of a wind noise acting on the system where the wind noise introduces a pressure imbalance between the front and rear inlets. The components V_F, R_6, C_3, R_7, and V_R have been fixed to values that would approximate the pressure imbalance inputs of a certain wind noise that is shown in **FIG. 8B**. The magnitude of V_R is chosen to be half the magnitude of V_F, which is provided by an assumption that one sound inlet of the microphone is midway between the origin of the wind turbulence and the second sound inlet. Thus, **FIG. 6** models a sound input that has no pressure imbalance between the front and rear inlets, whereas **FIG. 8A** has introduced components that model a pressure imbalance associated with that sound input.

[0048] **FIG. 8B** represents the two types of sound inputs for the model of the directional microphone conditions illustrated in the acoustical network **90** in **FIG. 6** or the acoustical network **100** in **FIG. 8A**. The horizontal Plane Wave Source at 74 dB SPL is representative of conversational speech. The Wind Noise Source has a high SPL at the low frequencies and has been selected based on a paper which suggests a level of 98 dB SPL at 100 Hz for a wind with a velocity of 10 miles/hour. This paper titled, "Electronic Removal Of Outdoor Microphone Wind Noise" by Shust et al., was presented at the 136th Meeting of the Acoustical Society of America, in October of 1998, and is incorporated herein by reference in its entirety.

[0049] **FIGS. 8C and 8D** illustrate the voltage outputs of a standard directional microphone (i.e., one that lacks R_{wc} and L_{wc} shown in the acoustical networks **90** and **100**) and a wind-noise suppressed directional microphone of the present invention, respectively, for the input sound sources of **FIG. 8B**. Three curves are shown in **FIGS. 8C and 8D**. Curve **1**, identified as "Constant 74 dB SPL Plane Wave at 0° Incidence," is representative of constant Conversational Speech at 74 dB SPL. Curve **2**, identified as "Wind Noise as Plane Wave at 0° Incidence," is representative of the Wind Noise as a Plane Wave with no pressure imbalance (i.e., the Wind Noise Source of **FIG. 8B** inputted into the acoustical network **90** of **FIG. 6** where $V_r=V_f$). Curve **3**, identified as "Wind Noise With Pressure Imbalance at **0°** Incidence," is representative of the Wind Noise with a pressure imbalance (i.e., the Wind Noise Source of **FIG. 8B** inputted into the acoustical network **100** of **FIG. 8A** where $V_r=0.5V_f$). Curve **3** is the most complete model for wind noise. Note that the curves do not represent frequency responses but, instead, output responses of a directional microphone as the source sound characteristics are being inputted into the directional microphone.

[0050] The difference between Curves **1** and **3** in both **FIGS. 8C and 8D** remains unchanged, meaning that the directional microphone's output from a wind noise source with a pressure imbalance (Curve **3** in both **FIGS. 8C and 8D**) relative to that of conversational speech source (Curve **1** in both **FIGS. 8C and 8D**) is the same for a standard directional microphone as well as the directional microphone having the wind noise suppression feature according to the present invention. A difference between a wind noise suppressed and a standard directional microphone is the 12 dB/octave roll-off instead of a 6 dB/octave roll-off. Consequently, there is much less tendency for the microphone elements to overload because of the high output at low frequencies that is characteristic of wind noise.

[0051] Further, there is also much less likelihood for low frequency masking by the wind noise of the higher frequencies of the speech signal. Notice that Curve **1** (conversational speech) in **FIG. 8D** exceeds the maximum level produced by wind noise. Accordingly, the masking effect of wind noise is not as prominent. Consequently, it is easier to hear the speech signal in the presence of a wind noise source when the present invention is employed on directional microphones.

[0052] There is another useful benefit derived from the directional microphone of the present invention. Wearers of directional hearing aids (i.e., those that have directional microphones) often found that the high frequency boost afforded by the microphone was an advantage. As a result, pressure microphones were designed with a 6 dB/octave roll-off at low frequencies. These pressure microphones were also found to be beneficial so they were modified with a 12 dB/octave roll-off to increase the effect even more. Consequently, a directional microphone with a high frequency boost appeared to be beneficial for speech understanding in certain situations.

[0053] **FIG. 9** illustrates that different values of the acoustical resistance and inertance of wind noise suppression channels/tubes can result in different frequency response shapes. Here, the input is simply a 74 dB SPL plane wave input. A standard directional microphone that lacks wind noise suppression channels/tubes is also illustrated for the sake of comparison. Accordingly, diameters and lengths of the wind noise suppression channels/tubes can be selected to

achieve a particular output response. Further, the internal surface structure of the wind noise suppression channels/tubes (e.g., a roughened surface to create more resistance or a more elliptical or bubbled shape having a varying cross-sectional area along the length of the wind noise suppression channels/tubes) can be altered to achieve desirable R_{wc} and L_{wc} values. For example, a tube having a length of 5 mm and a diameter of 0.58 mm has an inductance of 300 mH CGS and a resistance of 340 Ohms CGS. A tube with half the length (i.e., 2.5 mm) and a diameter of 0.4 mm has an inductance of 100 mH CGS and a resistance of 680 Ohms CGS. In any case, as compared to a standard directional microphone, the directional microphone according to the present invention preferably has lower sensitivity (i.e., a larger roll-off) for frequencies below about 500 Hz and, even more preferably, for frequencies below about 2.0 kHz.

[0054] **FIG. 10** illustrates a directional microphone **110** and a cutaway surface view of a faceplate or mounting plate **112** which includes a wind noise suppression conduit **114**. The microphone **110** includes a front inlet **116**, a back inlet **118**, and a housing **120**. When the housing **120** and the mounting plate **112** are positioned against each other, the front inlet **116** is connected to the back inlet **118** via the conduit **114**. The shape and geometry of the conduit **114** is selected according to one or more of the parameters set forth above in order to achieve desired resistance and inductance values, R_{wc} and L_{wc}, respectively. For example, in alternate embodiments, the cross sectional shape of the conduit **114** may be circular or elliptical, C-shaped, or rectangular, and the shape may be constant or varied along the length of the conduit **114**. The internal surface structure of the conduit **114** may be smooth or varied to create more resistance, for example. In the illustrated embodiment shown in **FIG. 10**, the conduit **114** is a hollow tube that connects the front inlet **116** and the back inlet **118** via the front conduit opening **122** and back conduit opening **124**.

[0055] In another embodiment, the conduit **114** is a channel or groove formed on the surface of the mounting plate **112**, and is closed by positioning a bottom surface of the microphone **110** over the conduit **114**. In yet another embodiment, the conduit **114** is formed in the mounting plate **112** such that one of the surfaces of the conduit **114** is defined by an outer surface **126** of the microphone **110**. In still another embodiment, the microphone **110** does not include openings **122, 124**, and the conduit **114** is positioned in the mounting plate **112** ahead of the front inlet **116** and back inlet **118**.

[0056] The directional microphone of the present invention is useful for all listening devices, including hearing aids. The audio signals from the directional microphone according to the present invention can be amplified by an amplifier and, subsequently, sent to a receiver that broadcasts an amplified acoustical signal to the user of the listening device.

[0057] While the present invention has been described with reference to one or more particular embodiments, those skilled in the art will recognize that many changes may be made thereto without departing from the spirit and scope of the present invention. Each of these embodiments and obvious variations thereof is contemplated as falling within the spirit and scope of the claimed invention, which is set forth in the following claims.

What is claimed is:

1. A directional microphone, comprising:

a housing;

a diaphragm dividing said housing into a front volume and a back volume;

electronics for detecting signals corresponding to movements of said diaphragm;

a front inlet to said front volume;

a back inlet to said back volume; and

an elongated acoustical conduit connecting said front volume and said back volume.

2. The directional microphone of claim 1, said directional microphone having a 6 dB/octave low frequency roll-off, wherein said acoustical conduit is configured to have an acoustical inertance to provide an additional 6 dB/octave low frequency roll-off.

3. The directional microphone of claim 1, wherein said acoustical conduit is positioned within said diaphragm.

4. The directional microphone of claim 1, wherein said diaphragm has a support structure holding said diaphragm in said housing, said acoustical conduit being positioned within said support structure.

5. The directional microphone of claim 1, wherein said acoustical conduit has acoustical characteristics that are predominantly inductive, rather than resistive.

6. The directional microphone of claim 1, wherein said front and back inlets include inlet tubes.

7. The directional microphone of claim 6, wherein said inlet tubes include a screen structure.

8. The directional microphone of claim 1, wherein said acoustical conduit has a length of from about 1 mm to about 6 mm.

9. The directional microphone of claim 1, wherein said acoustical conduit is positioned external to said housing.

10. The directional microphone of claim 1, wherein said acoustical conduit has a diameter of from about 0.05 mm to about 0.5 mm.

11. The directional microphone of claim 1, wherein said directional microphone has a frequency response curve with a 12 dB/octave roll-off at frequencies below about 2.0 kHz.

12. The directional microphone of claim 1, wherein said acoustical conduit presents an acoustical inductance of at least 100 mH as represented by the electrical analogy.

13. The directional microphone of claim 1, wherein said acoustical conduit is a cylindrical tube.

14. The directional microphone of claim 13, wherein said cylindrical tube is integrally formed within walls of said housing.

15. A directional microphone, comprising:

a moveable structure producing signals responsive to sound energy and dividing a front volume from a back volume, said front volume and said back volume being exposed to the environment for receiving said sound energy; and

a wind noise suppression conduit acoustically connecting said front volume and said back volume.

16. The directional microphone of claim 15, wherein said wind noise suppression conduit is located external to a housing in which said moveable structure is disposed.

17. The directional microphone of claim 15, wherein said wind noise suppression conduit is located within a housing in which said moveable structure is disposed.

18. The directional microphone of claim 15, wherein said wind noise suppression conduit is formed by a housing in which said moveable structure is disposed and a mounting plate positioned against said housing.

19. The directional microphone of claim 15, wherein said directional microphone has a frequency response curve with a 12 dB/octave low frequency roll-off at frequencies below about 2.0 kHz.

20. The directional microphone of claim 15, wherein said directional microphone has a frequency response curve with a 12 dB/octave low frequency roll-off at frequencies below about 500 Hz.

21. The directional microphone of claim 15, wherein said wind noise suppression conduit has a length of from about 1 mm to about 6 mm.

22. The directional microphone of claim 21, wherein said wind noise suppression conduit has a diameter of from about 0.05 mm to about 0.5 mm.

23. The directional microphone of claim 15, wherein said wind noise suppression conduit has a diameter of from about 0.05 mm to about 0.5 mm.

24. The directional microphone of claim 15, wherein said wind noise suppression conduit is formed by a housing of said directional microphone and a mounting plate positioned against said housing and connects sound inlets leading to said front and back volumes.

25. The directional microphone of claim 15, wherein said wind noise suppression conduit is located external to a housing of said directional microphone and connects sound inlets leading to said front and back volumes.

26. The directional microphone of claim 25, wherein said wind noise suppression conduit has a circular internal opening.

27. The directional microphone of claim 25, wherein said wind noise suppression conduit has a rectangular internal opening.

28. The directional microphone of claim 25, wherein said wind noise suppression conduit is formed at least in part by walls of said housing.

29. The directional microphone of claim 28, wherein said wind noise suppression conduit is formed entirely by said walls of said housing.

30. The directional microphone of claim 15, wherein said wind noise suppression conduit is located internal to a housing of said directional microphone and extends between said front and back volumes.

31. The directional microphone of claim 30, wherein said wind noise suppression conduit is integrally formed within the walls of said housing of said directional microphone.

32. The directional microphone of claim 30, wherein said wind noise suppression conduit is a tubular structure that extends through a support frame supporting said moveable structure.

33. The directional microphone of claim 15, wherein said wind noise suppression conduit presents an acoustical inductance of at least 100 mH as represented by the electrical analogy.

34. The directional microphone of claim 15, further including a second wind noise suppression conduit acoustically connecting said front volume and said back volume.

35. The directional microphone of claim 34, wherein one of said second wind noise suppression conduits is internal to a housing of said directional microphone and another is external to a housing of said directional microphone.

36. A method of suppressing wind noise in a directional microphone having a front and back volume, comprising:

acoustically connecting said front volume and said back volume with an elongated conduit having an acoustical inertance.

37. The method of claim 36, wherein said connecting occurs between a front inlet tube leading into said front volume and a back inlet tube leading into said back volume.

38. The method of claim 37, wherein said front inlet tube and said back inlet tube includes a screen structure, said elongated conduit being connected to said front and back inlet tubes downstream of said screen structures.

39. The method of claim 36, wherein said connecting occurs internally within said microphone across a diaphragm dividing said front volume and said back volume.

40. The method of claim 36, wherein said acoustical inertance provides an additional 6 dB/octave low frequency roll-off in addition to the 6 dB/octave low frequency roll-off in said directional microphone.

41. The method of claim 36, wherein said elongated conduit has a length of from about 1 mm to about 6 mm.

42. The method of claim 36, wherein said elongated conduit has a diameter of from about 0.05 mm to about 0.5 mm.

43. The method of claim 36, wherein said acoustical inertance provides said directional microphone with a frequency response curve with a 12 dB/octave low frequency roll-off at frequencies below about 2.0 kHz.

44. The method of claim 36, wherein said acoustical inertance presents an acoustical inductance of at least 100 mH as represented by the electrical analogy.

45. A method of preventing a low frequency overload due to wind noise in a directional microphone having a front volume and a back volume separated by a diaphragm, comprising:

adding an acoustical inductive element in parallel with said diaphragm.

46. The method of claim 45, wherein said adding includes connecting said front volume and said back volume with an elongated acoustical conduit.

47. The method of claim 46, wherein said adding includes connecting inlets to said front volume and said back volume at a location external to a housing of said directional microphone.

48. The method of claim 46, wherein said adding includes connecting said front volume and said back volume at a location internal to a housing of said directional microphone.

49. A listening device, comprising:

a directional microphone including a wind-noise suppression conduit and a diaphragm producing input audio signals responsive to sound energy, said diaphragm dividing a front volume from a back volume within said microphone, said wind-noise suppression conduit acoustically connecting said front volume and said back volume;

an amplifier for amplifying said audio signals into amplified audio signals; and

a receiver for converting said amplified audio signals into acoustical signals broadcast to a user of said hearing aid.

50. The listening device of claim 49, wherein said wind noise suppression conduit is located external to a housing of said directional microphone.

51. The listening device of claim 49, wherein said wind noise suppression conduit is located within a housing of said directional microphone.

52. The listening device of claim 49, wherein said noise suppression conduit is formed between a housing of said directional microphone and a mounting plate positioned against said housing.

53. The listening device of claim 49, wherein said listening device is a hearing aid.

54. A listening device comprising:

a directional microphone including a first inlet and a second inlet for receiving sound energy and a diaphragm producing input audio signals responsive to said sound energy, said diaphragm dividing a front volume from a back volume within a housing of said microphone; and

a mounting plate positioned against said microphone; and

a wind-noise suppression conduit forming an acoustical pathway between said front volume and said back volume of said microphone, said wind-noise suppression conduit being at least partially defined by said mounting plate.

55. The listening device of claim 54, wherein said wind-noise suppression conduit is defined entirely by said mounting plate.

56. The listening device of claim 55, wherein said wind-noise suppression conduit is a hollow tube internal to said mounting plate.

57. The listening device of claim 54, wherein said wind-noise suppression conduit is defined by said mounting plate and an outer surface of said housing.

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